TRANSNATIONAL SCIENCE AND TECHNOLOGY CO-OPERATION IN AFRICA: AN EVALUATION OF SELECTED INSTITUTIONS AND PROGRAMMES

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DECLARATION

I, the undersigned, hereby declare that the work contained in this dissertation is my own original work and that I have not previously, in its entirety or in part, submitted it to any other university for a degree.

ABSTRACT

In the aftermath of the Second World War, the development challenges facing Third World countries – those that were independent, those emerging from colonialism and those still under colonialism – led to the proliferation of bilateral and multilateral development institutions. These institutions were intended to assist the developing countries in terms of the provision of both human (technical) skills and material resources as well as to formulate programmes that would promote co-operation for socio-economic development and transformation. If the enormous development problems facing Africa including poverty, hunger, disease can be alleviated, then multilateral institutions have a major role to play in its scientific and technological development as well as in helping to create the appropriate institutional mechanisms for regional and sub-regional co-operation in science and technology (S&T) in Africa.

The United Nations system, including UN-affiliated institutions, has therefore come to represent the best hope of realising the dream of most developing countries in their quest for development, due to its institutional capacity to provide development assistance as well as influence the international development agenda which affects Africa. For example, among the institutions in this study, the World Bank Group remains the biggest donor organisation in terms of the funding of development projects and programmes. UNESCO has a leading role as the UN agency whose mandate relates directly to S&T development and peace. The ECA is the representative body of the UN in Africa and therefore able to influence the direction of development policy and programmes. Similarly, the need to develop also led African countries to establish their own regional and sub-regional institutions for co-operation to draw together both human and material resources.

However, the development issues discussed and promoted in the developing world over the years have focused more on national income, terms of trade, market access and in recent times on structural adjustment and poverty reduction strategy programmes. But the most important aspect of the development process – the knowledge capability gap (in terms of S&T) – has been much neglected especially at the regional and sub-regional levels.

Therefore, in using regional and sub-regional levels of analyses, the research project looks at the programmes supported by the following institutions: the United Nations Education, Scientific and Cultural Organisation (UNESCO), the World Bank, United Nations Economic

Commission for Africa (ECA), Organisation of African Unity (OAU), the African Development Bank (AfDB), the Southern African Development Community (SADC) and the Economic Community of West African States (ECOWAS). Thus the study uses a theory-driven evaluation based on INEXSK (INfrastructure, EXperience and Skills, and Knowledge) approach broadly, to investigate the extent to which these multilateral institutions live up to their stated goals of improving the knowledge base for development in the African continent. An important aspect of the study also entails a historical review of science, technology and institutional co-operation in Africa.

Furthermore, an important outcome of the study reveals the lack of functional regional and sub-regional organisational frameworks to promote rigorous scientific and technological research and development in the African continent, except for a few centres and programmes supported by some multilateral and bilateral institutions including NGOs. In spite of many years of structural adjustment the World Bank's lending for S&T has marginalised African countries; while the AfDB support for S&T and regional programmes is woefully inadequate. This is a momentous task it has to address if the *NEPAD* Initiative is to be successful in the years ahead. To guide future initiatives the study draws on the lessons and experiences of the European Union's and the Association of South East Asian Nations' (ASEAN) regional scientific and technology co-operation programmes. The study advocates a knowledge-based development paradigm, which is transnational in approach, and it makes specific recommendations for regional and sub-regional programmes and strategies to promote the socio-economic development and transformation of Africa.

OPSOMMING

Ná afloop van die Tweede Wêreldoorlog het Derde Wêreldlande – dié reeds onafhanklik, óf besig om kolonialisme af te skud, óf nog steeds onder 'n koloniale moondheid se bewind - sekere ontwikkelingstruikelblokke en -uitdagings in die gesig gestaar. Dit het gelei tot die totstandkoming van verskeie bilaterale en multilaterale ontwikkelingsinstellings. Die doel met sulke instellings se hulpverlening aan ontwikkelende lande was drieledig: om tegniese vaardighede aan te bied; om materiële hulpmiddele te verskaf; en om programme, wat samewerking vir sosio-ekonomiese ontwikkeling en transformasie sou bevorder, te formuleer. Indien die las van die geweldige ontwikkelingsprobleme in Afrika (insluitend armoede, hongersnood en siektes) verlig sou kon word, het multilaterale instellings 'n belangrike rol om te vervul: om te help met, enersyds, die wetenskaplike en tegnologiese ontwikkeling van die kontinent, en andersyds die ontwikkeling van toepaslike institusionele meganismes vir streek- en sub-streeksamewerking in wetenskap en tegnologie (W&T).

As gevolg van die Verenigde Nasies se institusionele kapasiteit om ontwikkelingshulp te verskaf, asook om die internasionale ontwikkelingsagenda te beïnvloed, verteenwoordig dié stelsel die beste hoop van die meeste ontwikkelende lande om hulle ontwikkelingsdrome te verwesenlik. Van die instellings wat by die VN geaffillieer is, en wat in hierdie ondersoek geëvalueer word, is die Wêreldbankgroep, die grootste skenkerorganisasie vir die befondsing van ontwikkelingsprogramme en –projekte. So ook het UNESCO 'n leiersrol as die VN-agentskap van wie die mandaat direk betrekking het op die ontwikkeling van W&T. Die EKA is die liggaam wat Afrika verteenwoordig by die VN, en beïnvloed daarom die koers van ontwikkelingsbeleid en –programme. Die noodsaak om die kontinent te ontwikkel het ook gelei daartoe dat Afrikalande hulle eie streek- en sub-streekliggame, wat menslike en materiële hulpbronne bymekaarbring, begin stig het.

Die ontwikkelingskwessies wat oor die jare in die ontwikkelende wêreld bespreek en aangemoedig is, het egter meer en meer gefokus op nasionale inkomste, handelsvoorwaardes, toegang tot markte en, in die afgelope tyd, strukturele aanpassings en armoedeverligtingstrategieprogramme. Die belangrikste deel van die ontwikkelingsproses – die vernouing van die kennisgaping in W&T - is gevolglik afgeskeep, veral op streek- en sub-streekvlak.

Hierdie navorsingsprojek analiseer dus, op streek- en sub-streekvlak, ontwikkelingsprogramme wat deur die volgende instansies ondersteun word: die Verenigde Nasies se Opvoedkundige, Wetenskaplike en Kulturele Organisasie (UNESCO), die Wêreldbank, die Verenigde Nasies se Ekonomiese Kommissie vir Afrika (EKA), die Organisasie vir Afrika-eenheid (OAE), die Ontwikkelingsbank van Afrika, die Suider-Afrikaanse Ontwikkelingsgemeenskap en die Ekonomiese Gemeenskap van Wes-Afrikaanse State. Die navorsing gebruik 'n teorie-gedrewe evaluering gebaseer op 'n INEXSK ("INfrastructure, EXperience and Skills, and Knowlege") benadering, om te bepaal in watter mate hierdie multilaterale instellings hulle doelwitte, met betrekking tot die verbetering van die kennisbasis vir ontwikkeling van die Afrika-kontinent, bereik. 'n Historiese oorsig van die wetenskaplike, tegnologiese en institusionele samewerking in Afrika vorm 'n belangrike deel van die navorsingsverslag.

Die navorsing dui ook op 'n gebrek aan funksionele organisatoriese raamwerke om op streek- en sub-streekvlak streng wetenskaplike en tegnologiese navorsing en ontwikkeling aan te wakker en te bevorder. (Daar is darem 'n paar noemenswaardige uitsonderings van sentra en programme wat deur party van die bilaterale en multilaterale instellings ondersteun word.) Ten spyte van strukturele aanpassings wat oor baie jare plaasgevind het, het die Wêreldbank se lenings vir W&T Afrikalande gemarginaliseer; en die Ontwikkelingsbank van Afrika se ondersteuning vir W&T en streeksprogramme is heeltemal ontoereikend. Daar is 'n geweldige taak wat in die toekoms aangespreek moet word indien die NEPAD inisiatief hoop om suksesvol te wees.

Die verslag gebruik die lesse en ervarings van die Europese Unie en die Vereniging van Suid-Asiatiese Lande se streeksamewerkingsprogramme vir wetenskap en tegnologie as rigtingwyser vir toekomstige inisiatiewe. Die verslag beveel 'n transnasionale kennisgebaseerde ontwikkelingsparadigma aan, en maak spesifieke aanbevelings vir streek- en sub-streekprogramme en strategieë om die sosio-ekonomiese ontwikkeling en transformasie van Afrika te bevorder.

DEDICATION

This work is dedicated to all people
in the quest for scientific knowledge
and its peaceful application
in the development of Africa,
by fighting poverty, hunger
and disease in Africa.

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CHAPTER ONE

INTRODUCTION

We all live on the same planet and are part of the biosphere. We have come to recognize that we are in a situation of increasing interdependence, and that our future is intrinsically linked to the preservation of the global life-support systems and to the survival of all forms of life. The nations and scientists of the world are called upon to acknowledge the urgency of using knowledge from all fields of science in a responsible manner to address human needs and aspirations without misusing this knowledge. We seek active collaboration across all the fields of scientific endeavour, that is the natural sciences such as the physical, earth and biological sciences, the biomedical and engineering sciences, and the social and human sciences ... All cultures can contribute scientific knowledge of universal value. The sciences should be at the service of humanity as a whole, and should contribute to providing everyone with a deeper understanding of nature and society, a better quality of life and a resourceful and healthy environment for present and future generations.

[Declaration on Science and the Use of Scientific Knowledge, UNESCO World Conference on Science, 26 June-1 July1999.]

1.1 THE RESEARCH PROBLEM AND CONTEXT

Since the Second World War the concerns about development have led to the creation of international institutions to foster the socio-economic advancement of the Third World, of which Africa is part. These institutions were to help provide both human (technical) skills and material assistance to developing countries, most of which were emerging from colonialism. The need to develop also led African countries to establish their own regional and sub-regional institutions for co-operation to draw together both human and material resources.[1]

Such development, however, has eluded many of the developing countries, with a result that the institutional mechanisms for co-operation need to be evaluated. For instance, the World Bank is an institution created by the international community to provide long-term loans to developing countries. The World Bank group is the single and largest source of development assistance to developing countries. We therefore need to understand the Bank's policy on the building of scientific and technological capability in developing countries in general, and in Africa in particular. Moreover, following the Rio de Janeiro United Nations Earth Summit and the adoption of Agenda 21 in 1992, the World Bank has increasingly been involved in

[1] By 1990 there were over 200 intergovernmental organisations established by African countries for regional and subregional cooperation and integration, with West Africa alone having over 32 such institutions (see Martin, 1992; McCarthy, 1998).

the issue of sustainable development. Since Agenda 21 gives important recognition to science and technology (S&T) in maintaining a healthy Earth in the midst of socio-economic development, it is worth evaluating such an institution. Africa needs to know what it has gained through international institutions that have been established to serve its development efforts through institutional co-operation in building knowledge for development in Africa.

Similarly, there is a need to take stock of the institutions that African countries have established and how far they have been able to promote scientific and technological development. With the recent emphasis on sustainable development, it is not surprising that economic development and environmental protection head national, regional and international development agendas at present, all of which require the application of modern science and technology.

The improvement of national and regional competitiveness in the global economy has stimulated scientific and technological co-operation in the European Union over the years. The other aspect – apart from competition – is to improve the employment situation within the European Union (André, Fasella & Ruberti, 1998:91). An example of European technological co-operation in this direction is the Airbus. The Airbus family has grown from being medium-sized and large passenger aircraft and taken over 30% of the world civil aviation market. Operated as an Economic Interest Grouping among the Aérospatiale of France, British Aerospace of UK, DASA of Germany and CASA of Spain, the Airbus is in the process of acquiring the status of a genuinely European company (André, Fasella & Ruberti, 1998:91).[2] This is because institutions provide the leverage through which individual members may realise their developmental dreams.

Although it is not possible to provide any guarantee for the realisation of such dreams in Africa, the need to examine and evaluate such international co-operative institutions and their programmes must be clear from this example. This study therefore departs from the premise that scientific and technological co-operation should be a priority of every country in Africa. As Forje (1989:189) puts it: "... any African country which elects to reject technological and scientific co-operation and progress is bound to be bypassed by world events because of the fierce competition among nations and in view of the many varied advances in scientific and technological achievements. This is more true as interdependence increases so that each

[2] This is threatening and at the same time weakening the virtual monopoly of the American aircraft industry in the world civil aviation market, particularly Boeing.

country is more dependent on others for some of the resources needed to maintain and even increase its output."

More importantly, the concern with science and technology as one of the major vehicles of development in the developing world has been well diffused throughout the United Nations (UN) system, to the extent that virtually all the specialised agencies of the UN are in one form or another concerned with some aspect of science and technology for development and peace. As Morehouse (1985:294) puts it, United Nations Education, Scientific and Cultural Organisation (UNESCO) has science enshrined in its name. The World Health Organisation (WHO) and the Food and Agricultural Organisation (FAO) have programmes on S&T; the United Nations Conference on Trade and Development (UNCTAD) is concerned with enhancing developing countries' access to the technologies of industrialised countries through its Technology Division; while the United Nations Industrial Development Organisation (UNIDO) aims at strengthening technology as a critical factor in the industrial development of developing countries. Last but not the least, the UN Centre on Transnational Corporations is involved in the analysis of the impact of multinational companies on development through direct foreign investments by these companies and the acquisition of technologies by the developing world. In addition to these agencies, following the first United Nations Conference on the Application of Science and Technology for the benefit of Less Developed Areas, the United Nations Advisory Committee on the Application of Science and Technology to Development (ACAST) was created in 1964, while the intergovernmental Committee on Science and Technology for Development (CSTD) was established with its terms of reference adopted in Geneva in July 1972, during the Second UN Development Decade from 1971-1980 (see Gresford & Châtel, 1974).

The main research problem to be investigated in this study is thus the extent to which existing multilateral programmes and institutions for S&T co-operation in Africa live up to their stated goals of improving the knowledge base for development on the continent.

1.2 THE PURPOSE OF THE STUDY

The aim of this study is to examine critically:

- The implications of development theory and institutional theory for the development of S&T and how this pertains to Africa;
- The functions of international institutions including the World Bank, United Nations

Education, Scientific and Cultural Organisation (UNESCO), and the United Nations Economic Commission for Africa (ECA) in the development of S&T on the continent;

- The functions of Africa's own institutions and programmes such as the African Development Bank and the Organisation of African Unity at the continental level, and sub-regional institutions such as the Southern African Development Community (SADC) and the Economic Community of West African States (ECOWAS) and their development of S&T;
- The lessons Africa can learn from past experiences of other developing countries and regions including the Association of South East Asian Nations (ASEAN) and the European Union (EU).

On the basis of these analyses, some recommendations will be made on how the institutional challenges in terms of S&T development can be addressed in the twenty-first century to enhance the socio-economic development of Africa.

1.3 RATIONALE

As the twentieth century closes developing countries are still grappling with the concept of development and its consequences. The new development paradigm has become knowledge based. Studies conducted among the Organisation for Economic Co-operation and Development (OECD) member countries have estimated that more than 50% of the Gross Domestic Product (GPD) is now knowledge based (OECD Observer, 1996:6; OECD, 1996; World Bank, 1998) in the major OECD economies, for example. This development gives credence to the views expressed by some scholars on the importance of knowledge, including its scientific and technological components, in the international political economy (see Strange, 1988; Stehr 1994; Vorster & Nel, 1995; Singleton, 1996).

With scientific and technological advancement being measure of socio-economic development and of a nation's competitiveness in the international political economy,[3] the level of sophistication of scientific and technological development has become an important tool for gaining power in the global community. As a result science and technology have not only affected the capability of states and the availability of the means of pursuing and

[3] Science and technology is one of the eight main elements considered in the compilation of the World Competitiveness Report, The United Nations Development Human Development Report 2001 is also based on technology.

attaining goals, but have impacted on aspects of international relations as well, including the structure of the international system and the definition of purposes and objectives of states (Fox, 1970). The fundamental and political role of governments in nurturing scientific and technological development should therefore be of great concern to Africa.

The African continent is one of the geopolitical regions of the world that is confronted with huge developmental problems. Poverty, hunger, disease and an increasing number of political conflicts characterise the continent. In order to fight these scourges successfully, many theorists, policy-makers and academics believe that Africa must increase its output in the global economy through science-led development (Odhiambo, 1991; Adeboye, 1998; Kerre, 1999). For that purpose its vast natural resources need to be exploited and increased in value. In fact, under the Lagos Plan of Action for Economic Development of Africa (1980-2000) it was envisioned that by the year 2000 Africa would be socio-economically integrated with a high level of intra-African trade in African products, services and technologies. This, it was hoped, would contribute at least 2 percent of world industrial output. Therefore, developing Africa's scientific and technological capabilities is considered the most critical issue at the dawn of the 21st century.

The resources of the Gulf of Guinea ecosystem and the offshore petroleum production serve to emphasise this point of view. While they contribute about US$3.8 billion annually to the developing economies of the coastal countries in West Africa, experts (at The National Summit on Africa, 1998) estimated that, with more sustainable use of the marine resources through an appropriate application of scientific and technological knowledge, this can be improved upon considerably. It has been suggested that the annual contribution of these resources to the economies of the region could be increased to US$9 billion within the next few years.

Since the mid 1970s the structure of international trade in goods has changed dramatically. Almost 50 percent of trade at the start of this period consisted of primary resource products, whereas a high proportion of the present trade is in technology-intensive goods. Thus, high-technology products alone have doubled their share of world merchandise exports from 11 percent of the total composition in 1976 to 22 percent in 1996, while the share of primary products dropped to less than 25 percent from about 45 percent in 1976 (World Bank, 1999:27). A similar study by the Organisation for Economic Co-operation and Development (OECD) shows that since 1980 exports and imports of high-technology products have grown faster than those of other manufacturing sectors. That is, high-technology trade accounted for 10 percent of manufacturing exports and imports in 1980, but had risen to almost 17 percent by 1994. Among the high-technology sectors are aerospace, computers and office equipment, electrical machinery, pharmaceuticals and scientific equipment (OECD, 1999). Therefore the relationship between science and economic growth and development can be viewed in a more positive light, notwithstanding the counter-arguments often put forward by some post-development theorists and analysts who tend to put more emphasis on the negative consequences of S&T (see Chapter 2).

The problem, however, is that the national systems of innovation (NSI) which is the "network of institutions in the public and private sectors whose activities and actions initiate, import, modify and diffuse new technologies" (Freeman, 1987 cited in OECD, 1997:10), of many of the countries in Africa are either in crisis or are suffering under severe resource constraints.[4] For example, analysis of all standardised indicators shows that Africa is faring poorly in the S&T stakes. Even though the overall validity of some of these indicators as measures of the input and output of knowledge can and have been challenged, the cumulative outlook that emerges from them is that S&T in sub-Saharan Africa (SSA) is seriously lagging behind most other regions of the world, including some developing regions at the turn of the 21st century. For example, although gross expenditure on research and development (GERD) in Sub-Saharan Africa (SSA) is said to have increased from US$1,09 billion in 1992 to US$2,3 billion in 1994, and as a percentage of gross domestic product (GDP), increased from 0.4 to 0.5%, these modest increases have not prevented SSA from sliding back on other input indicators and also in terms of outputs (see Adeboye, 1998; Nel & Teng-Zeng, 1999).

Compounding this problem is the fact that Africa does not have the necessary manpower and institutional requirements to undertake science-led developments. In the UNESCO *1996 World Science Report,* Papon and Barré (1996:14) have shown that in 1992 Africa as a whole had only 0.4 research and development (R&D) scientists for every 1 000 in the population, as opposed to the global average of 0.8. Besides, very few African students make it to the tertiary level or even engage in technical and vocational education at the secondary level.

[4] The NSIs often include the following interrelated areas: macroeconomic conditions and regulatory frameworks providing the environment for innovation in the private sector; national systems managing and co-ordinating S&T institutions; communications and information technology; the capacity to monitor and assess relevant information; mechanisms for linking academic institutions with society; programmes to educate and train personnel; scientific and technological know-how of the labour force; scientific and technological services and mechanisms to promote and facilitate the diffusion and transfer of technology; and financial intermediaries and resources etc (Inter-American Development Bank, 2000; and for more on NSIs see Nelson, 1993).

Although the percentage of tertiary students studying in S&T subjects compares well with other developing regions, the real problem is that so few African students get a tertiary education at all. Available figures (for the early 1990s) show that the People's Republic of China (PRC) had a better ratio than 14 SSA countries surveyed and that the best performers (The Democratic Republic of the Congo, Zimbabwe and South Africa) still lag behind Singapore by a factor of between five and seven (see Adeboye, 1998; UNESCO *World Education Report 1998*; Nel & Teng-Zeng, 1999). The Southern African Development Community's *Human Resources Development Report 1999-2000* notes the precarious situation facing human resource development, especially at the tertiary level, in the region. Noting the success at the primary level of education, the report states:

> The region continues to improve the development of education. Great strides have been made to achieve universal primary education. Three quarters of the SADC member States have met enrolment rates for primary education within the range 80-100% with Seychelles and Mauritius achieving 100% and 99% respectively. However, such high enrolment rates at the primary level are not accompanied by commensurate rates of enrolment at the secondary and higher levels of education. In some countries less than 50% of students progress to secondary school level while, on average, less than one percent of students in secondary education progress to higher education and training (SADC, 2000:1).

This low level of scientific and technological manpower and education and training at the higher level is aggravated by the high rate of "brain drain" from the continent. Excluding other professionals, studies sponsored by the Research and Development Forum for Science-Led Development in Africa (RANDFORUM) reveal that up to 30% of African scientists are lost due to the brain drain (Adeboye, 1998:180). Read against the background of William Fox's (1970:134) statement that "there is probably no other resource that can be made to serve so many alternative national purposes as a nation's scientific and technical manpower", the extent of Africa's problem is evident.[5]

The manpower problem has also been reflected in the global output of scientists and engineers in terms of publications. In 1995 the Science Citation Index (SCI) and Compumath databases provided the following figures on the distribution of scientific activity in the world: North America (38.4%), Western Europe (35.8%), Japan and the newly industrialising countries (NICs) (10.1%), the Commonwealth of Independent States (4.0%), Central and Eastern Europe (2.0%) and Sub-Saharan Africa (0.8%) (Barré, 1998:24). According to these

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[5] Even in the advanced countries great efforts are still being made to train more scientists and engineers. For example, Paul Romer (2000) is suggesting how universities in the USA could be given more carrots by the Federal government for turning out more science and engineering graduates.

statistics Sub-Saharan Africa had lost 19% of its world output since 1990.

This index of scientific publication to Gross Domestic Product (GDP) is not only linked to R&D expenditure, but also to the importance of academic research within national or regional R&D activity.[6] A number of studies have been carried out to highlight the importance of science and technology in the socio-economic development of Africa and in developing countries in general (Forje, 1979 and 1989; Wad, 1989; Ndebbio, 1992; Vitta, 1993; Jugessur, 1994; Ayiku, 1996; Adeboye, 1998).[7] In recent times virtually no major conference on the social and economic development of Africa has passed without a mention of the need for African countries to develop their scientific and technological capabilities individually and collectively to enhance their economic growth and development. These conferences and studies often pinpoint the need for African countries to evolve continental and regional institutional mechanisms for co-operation.[8] It has been suggested that this could be done by forging stronger bilateral ties and through multilateral agreement, either by their own efforts or with international institutions. These developments have led to renewed calls for international, continental and regional co-operative agreements with the requisite institutional mechanisms among African countries and with Africa's development partners.

The thesis of this study is that African development partners and African governments need to work together to address the problems in Africa. The high cost and complexities involved in building functional science and technology systems requires effective co-operation in pulling together both human and material resources. If those responsible for the establishment of institutions will ensure that they are functional, institutions have the advantage of enabling co-ordination and implementation. In this regard the *New Partnership for Africa's Development* (NEPAD) document, which calls for the provision of essential regional and sub-regional public goods including transport, energy, water, information and communication technologies, disease eradication, environment preservation and regional research capacity building among other things, needs to be noted here. Thus NEPAD prioritises the closing of the infrastructure gap and the creation of the necessary science and technology platforms,

[6] Such academic research activity can also improve the manpower capability of a country or region. For example, before the launching of the micro-satellite by the University of Stellenbosch in February 1999 in the USA, the SUNSAT Project had trained 55 MSc and 4 doctoral students.

[7] Under the Lagos Plan of Action for Economic Development of Africa, 1980-2000, the African heads of state and government emphasised the importance of systematic and integrated development and the use science and technology by the countries and people of Africa to spearhead development.

[8] OAU, 1991 *Abuja Protocol on Science and Technology,* UNECA, 1995 *First African Regional Conference on Science and Technology,* UNESCO, 1995 *Audience Africa,* US Government, 1998 *The National Summit on*

including human resource development and strategies to reverse the brain drain in Africa (NEPAD, 2001).

Thus a systematic analysis of the applicability of development theories in this study to the development needs of Africa will lead to recommendations for African countries to devise policy responses that may lead to capacity building in science and technology for development.

The most recent work by Enos (1995), for instance, was on Ghana, Kenya, Tanzania and Uganda. While on-going research by Jacques Gaillard and Roland Waast of the French Scientific Research Institute for Development and Co-operation (ORSTOM) and their African colleagues aims at assessing what Africa has achieved, but also concentrates on individual scientists in particular national contexts.[9] This study is intended to stimulate the debate on development co-operation through transnational institutions and programmes within the broader framework of the continent's needs. The 1991 Abuja Treaty (and its Articles 51 and 52) as adopted by the OAU Member States, the current debate on African Renaissance as exemplified by the NEPAD initiative and the Constitutive Act of the African Union as well as the broader framework of South-South co-operation all reflect a renewed interest in co-operation in S&T and all that this entails.

1.4 UNDERLYING ASSUMPTIONS

The main assumptions of this study are threefold. Firstly, given Africa's present level of development, the continent cannot move forward progressively without the development of scientific and technological capabilities. Secondly, sustainable development in the twenty-first century is impossible without technological co-operation between African countries and their development partners. Thirdly, functional international institutional mechanisms are needed to promote scientific and technological development in Africa.

No nation, including the advanced and industrialised countries, can effectively meet all its needs. Since Africa is lagging behind in economic development, it needs this co-operation more urgently than developed countries do. It is, however, argued that the onus to foster the development of their scientific and technological capabilities is on developing countries

Africa-Partner Programmes.

[9] The study includes 12 countries: Egypt, Morocco, Tunisia (North Africa) Cameroon, Ivory Coast, Nigeria, Senegal (West Africa) Ethiopia, Kenya, Tanzania (East Africa) and South Africa and Zimbabwe (Southern Africa).

themselves. They require stronger and more functional international institutions. Hence the current and crucial need for Africa to constantly evaluate the institutions that have been initiated in the continent as well as those created outside it and their programmes.

1.5 THEORETICAL FRAMEWORKS AND LEVELS OF ANALYSIS

The evaluative component of this study was guided by recent theories emphasising the role of knowledge in general and S&T in particular in development (e.g. Mansell & Wehn, 1998). Given the number of contending development theories which have evolved over the years, we pay special attention to the new emerging theoretical perspective of knowledge-based development to determine what such a theory entails, how it can contribute to the building of the scientific and technological capabilities of Africa in the twenty-first century, and to what extent it has influenced recent policies and programmes.

Secondly, an institutional approach has been adopted to highlight the importance of institutions in fostering international co-operation in what Sell (1998:11) calls "an anarchic world comprised of rational egoists" on account of the difficulties experienced in effecting co-operation in Africa to date. In the application of knowledge for development, we highlighted the importance of these institutions adopting a middle ground theoretical approach by combining knowledge-based development theory and the insights of post-development theory, and particularly views on the various forms of indigenous knowledge and how they can be shared.

This study focused on the transnational level of analysis, and specifically on its continental and sub-regional dimensions. As already mentioned, the existing literature on S&T in Africa focuses mostly on national capacity building (national level of analysis) rather than transnational co-operation, or it deals exclusively with the problems experienced by scientists (individual level of analysis). The concept "transnational" (and not "international") is preferred, because it reflects that cross-boundary co-operation does not necessarily relate only to state-to-state enterprises, that is *international* co-operation. In other words, transnational co-operation includes the participation of at least one non-state-actor, such as a non-governmental organisation (NGO) or a business enterprise (see for example, Keohane & Nye, 1971).

1.6 METHODOLOGY

The study is evaluative and has three components, namely:

- an overview of the selected institutions and programmes and their role in fostering S&T co-operation;
- an evaluation of these institutions and programmes by means of criteria developed from the knowledge-for-development literature;
- a set of policy suggestions for improving S&T co-operation on the continent.

The overview of the study was based on a comprehensive literature and documentary review, augmented by a number of structured interviews. In other words, the data collection for the overview of the institutions and programmes selected consisted of both primary and secondary sources. Marwick (1981:136) sees primary sources as the "basic, raw, imperfect evidence"; the primary source material can include documentary, statistical, archaeological, architectural, photographic evidence and interviews; while books, journal articles and other material already processed is considered as secondary source material (Phelan & Reynolds, 1996:116).[10]

For the purposes of gaining access to official publications and interviews as our primary materials, the data collection process in the study involved field research in some African countries, including Botswana, Ethiopia, Kenya and Nigeria, where the regional or sub-regional offices of the selected institutions are located. In Botswana interviews were conducted at the Secretariats of the Southern African Development Community and the Southern African Centre for Co-operation in Agricultural Research and Training (SACCAR) in Gaborone; in Ethiopia interviews were conducted at the regional head offices of the OAU and the United Nations Economic Commission for Africa as well as with the UNESCO regional representative, all based in Addis Ababa. Similar trips were made to Nairobi, Kenya to the UNESCO Regional Office, the OAU's Inter-African Bureau of Animal Research and the African Academy of Sciences. In Nigeria the trip involved data collection at the Secretariat of the Economic Community of West African States (ECOWAS) in Abuja and the OAU's Scientific, Technical and Research Commission regional office in Lagos. Also in Nigeria, an initiative was taken to visit the newly established Federal Ministry for Integration

[10] For more discussion on data sources and research methodology see for example, Kerlinger, 1986; Bless and Higson-Smith 1995; Mouton, 1996; Neuman and Benz, 1998; Neuman, 2000; Babbie, 2001.

and Co-operation in Africa, which was still in the process of developing a comprehensive programme for scientific and technological co-operation in Africa. Lastly, in South Africa a field trip was made to Pretoria to meet some representatives from Department of Foreign Affairs' Multilateral Branch, the Department of Arts Culture, Science and Technology, The Human Sciences Research Council, the National Research Foundation (NRF), the Council for Scientific and Industrial Research (CSIR), and UNESCO. In all these field trips an attempt was made to meet the experts and officers responsible for science and technology and related fields which seek to promote co-operation and development in Africa for discussion. The research material collection was further augment by extensive use of electronic sources through the Internet to access the homepages of the selected institutions in the study and other World Wide Web search engines, thus utilising ever-increasing information and communications technologies.

The programme evaluation is theory-driven and is also based on criteria developed in the extensive literature on knowledge for development. We emphasise a social science approach to programme evaluation, which means that "programme theory should be derived from information on both how the programme is actually operated and existing social science theory and knowledge" (Chen, 1990:67). In this instance we used knowledge-based development theory based on the INEXSK (Infrastructure, Experience and Skills, and Knowledge) approach as developed by Mansell and Wehn (1998). However, we broadened this approach to include other fields of knowledge, thereby not limiting our discussion to only information and communications technologies (ICTs), which are the basis on which Mansell and Wehn developed their approach for analysis (see Chapter 2 for more discussion on the theoretical approach). Furthermore, in the evaluation we also tried to understand the policy formulation and implementation processes and the financial resources of these institutions, especially since these have an impact on the development of infrastructure and human resource capacity building in Africa.

The policy suggestions at the end of the study are based on the preceding evaluations, as well as on a literature study of the comparative experiences of other regions in the world, including ASEAN and the EU, which have had more successes with S&T co-operation and thus integrating it in their development programmes and projects. We tried to limit personal biases by supporting expressed opinions with the appropriate documented evidence or empirical research findings as far as possible.

1.7 MOTIVES FOR SELECTION OF INSTITUTIONS AND THE LIMITATIONS AND DELIMITATIONS OF THE STUDY

There are several international institutions with programmes that cover (or relate to) science and technology for development. However, we have already mentioned the nine institutions we are going to study which include three international institutions, two regional institutions and two sub-regional as well as two other institutions which we examine for the lessons they hold for Africa in the field of scientific and technological co-operation. First and foremost, we took into consideration the continental and sub-regional purview of selected institutions and in terms of the available resources at the disposal of these institutions and therefore their programmes. UNESCO, the World Bank and the ECA have a presence in Africa and have developed policies and programmes thus making them our first choices international institutions. The OAU and the African Development Bank still remain the only institutionalised regional bodies created by African countries with presence in the continent. On the other hand, ECOWAS and SADC also represent the only sub-regional institutions for co-operation and integration with a longer history spanning two decades whose memberships cover former colonial boundaries with different languages and have much broader geographical areas. Besides, the availability of appropriate data for the study also influenced the selection of these institutions and the programmes that are chosen.

Some readers may be disappointed to find that institutions such as the United Nations Food and Agricultural Organisation and (FAO) and the World Health Organisation (WHO) have not been selected. We are aware of their significance for socio-economic development and transformation in Africa, but in view of resource and time constraints, a selection has to be made – and that is where the researcher's personal bias creeps in even though it may not necessarily be a bad one. The study also falls short of any detailed explanatory analysis of individual countries in Africa. Nevertheless, inferences are made from those countries that are playing leading roles to develop better mechanisms for scientific and technological co-operation for development in Africa, especially South Africa within the SADC region. Similarly, we tried to bring on the lessons of the Inter-American Development Bank even though it was not part of our main study.

1.8 DEFINITION OF TERMS

Science

The *Chambers Dictionary of Science and Technology* (2000:1021) defines science as "the ordered arrangement of ascertained knowledge, including the methods by which such knowledge is extended and the criteria by which its truth is tested". Mouton (1996:16) refers to science (or scientific knowledge) as the product or outcome of scientific research and he defines it as "the body of propositions ... that, at a given time, is accepted by the scientific community ... as being valid and reasonably sound". There are various forms of science: pure, applied and strategic (for further elaboration on the distinction, see discussion under R&D below).

Technology

Technology can be taken as a practical application of scientific knowledge for the benefit of human existence. The *Chambers Dictionary of Science and Technology* (2000:1150) defines technology in general terms as "the practice, description and terminology of any or all of the applied sciences which have practical value and/or industrial use". Westphal, Kim and Dahlman (1985:170) define technology as "a collection of physical processes that transform inputs into outputs, to the specification of the inputs and the outputs, and to the social arrangements that structure the activities involved in carrying out these transformations". According to them, technological knowledge has both technical and transactional elements; the former relate to product characteristics and physical processes, and the latter refers to the social arrangements involved in the processes of application. These social arrangements include various kinds of market and contractual relationships among entities, as well as organisational modes and procedural methods to regulate an entity's internal operations (Westphal, Kim & Dahlman 1985: 171).

Research and Development (R&D)

Following the line of UNESCO's (1978) *Recommendation Concerning the International Standardisation of Statistics on Science and Technology,* UNESCO defines R&D as "any creative systematic activity undertaken in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this knowledge to devise new applications" (UNESCO, 1995:5-1; see also OECD, 1994:29). Generally, scientific research is usually classified to into two broad categories: basic (fundamental) and applied (mission-oriented or tactical). On the one hand, basic research is considered as experimental or theoretical work with no immediate practical purpose in mind. Or it may be considered either as pure (or curiosity-oriented) or strategic research. Pure research corresponds to the idea of academic research carried out with the purpose of producing new knowledge primarily for its own sake, while strategic research is carried out with the expectation that it will produce a broad base of knowledge likely to form the background to the solution of recognised current or future practical problems. On the other hand, applied research "is directed primarily towards a specific practical aim or for finding possible uses for the existing findings of basic research" (Hall, 1994:20; see also OECD, 1994:68-70; Irvine & Martin 1984:4).[11] The development element of R&D (usually described as experimental development) involves "systematic but non-routine technical work directed towards producing new or improved materials, products and services, including the design and development of processes and prototypes" (Hall, 1994:20).

Co-operation

Robert Keohane (1984:51-52) observes in his book *After Hegemony: Co-operation and Discord* that "co-operation occurs when actors adjust their behaviour to the actual or anticipated preferences of others, through a process of policy co-ordination". For him *"intergovernmental co-operation takes place when the policies actually followed by one government are regarded by its partners as facilitating the realization of their own objectives, as the result of policy co-ordination"* (italics in original). Policy co-ordination involves a process of negotiation between separate individuals or organisations. A negotiation process usually accompanies transnational co-operation. Milner (1992:469) observes that co-operation can occur through tacit, negotiated or imposed behaviours among actors but, of the three, negotiation is the one most favoured by nations. This is because through negotiation the countries take part in the decisions reached and some of their concerns have to be taken into account.

Institutions

Robert Keohane (1989:3), a leading proponent of the institutional approach in the study of

[11] Paul Stoneman (1995:5) also argues that applied research can also be divided into strategic and non-strategic, with strategic research having longer-term, less explicit objectives and non-strategic research having shorter-term, more explicit objectives in view.

international relations defines institutions as "persistent and connected sets of rules (formal and informal) that prescribe behavioural roles, constrain activity and shape actors' expectations". For Keohane institutions can therefore assume three forms:

- firstly, formal intergovernmental or across-national non-governmental organisations. These organisations are said to be purposive entities with formal structures and headquarters, and are therefore often bureaucratic;
- secondly, international regimes, which are institutions with explicit rules and decision making procedures and without necessarily having formal structures such as operational headquarters agreed upon by actors, that pertain to particular sets of issues in international relations. These regimes are regarded as "negotiated orders" by Oran Young (1983:99);[12]
- lastly, conventions, which are considered informal institutions, with implicit rules and understandings, which shape the expectation of actors. Keohane (1989:4) acknowledges that we should not limit our frame of reference to only formal organisations or regimes in our discussions of international institutions. According to him, "conventions are not only pervasive in world politics but also temporally and logically prior to regimes or formal international organisation. In the absence of conventions, it would be difficult for states to negotiate with one another or even to understand the meaning of each other's actions. Indeed, international regimes depend on the existence of conventions that make such negotiations possible".

1.9 FORMS OF SCIENTIFIC AND TECHNOLOGICAL CO-OPERATION

With regard to international scientific and technological co-operation, Forje (1989:190-191) notes that it may take a number of forms: institutional, concerted or catalytic co-operation.

Firstly, institutional co-operation is "characterised by a common scientific and technological programme of action and a common budget fed by national contributions" which falls into two categories: intramural and extramural. According to Forje, in an intramural programme

[12] In an often cited definition, Steven Krasner (1983:2) defines regimes as "sets of implicit or explicit principles, norms, rules, and decision-making procedures around which actors' expectations converge in a given area of international relations. Principles are beliefs of fact, causation, and rectitude. Norms are standards of behaviour defined in terms of rights and obligations. Rules are specified prescriptions or proscriptions for action. Decision-making procedures are prevailing practices for making and implementing collective choice". For further discussion on regimes, see Hasenclever, Mayer and Rittberger, 1997.

the scientific activities and technological activities are carried out in a central institution bringing together scientific workers from all the participant countries. This category includes (i) international scientific and technological organisations created by a special international agreement, and (ii) national scientific and technological organisations with an international vocation. In an extramural programme scientific and technological activities are shared between branches operating in the various participating countries. As far as the current systems of programmes in Africa are concerned, neither intramural nor extramural co-operation exists, whether at the regional or sub-regional levels of analysis.

Secondly, concerted co-operation as identified by Forje is characterised by the co-ordination of international activities according to a commonly planned working programme. Thus the head of national teams meet at intervals to exchange and compare results of their work, which often requires the standardisation of methods. Each participating country is required to pay its own expenses; however, the costs incurred by the collaboration are usually borne by an international organisation.

The third form of co-operation, which is termed catalytic, involves attempts by an international organisation to promote a free and spontaneous exchange of information about and explanation of ongoing scientific and technological activities and their results between partners in different countries. Generally, this kind of exchange does not mean that before starting participants need first agree on a joint plan of action. Instead, co-operation tends to be *ex post facto*, and its intensity depends on the scheme adopted for making information available among participating countries. Catalytic co-operation sometimes also involves promotional action by the executing agency in the form of unconditional subsidies (as opposed to contracts). This approach involves the formal linking together of a number of national institutions working in a specific discipline or area of training with a view to promoting the facilitation of development in the field through regional communication and co-operation. The objective of the network is to strengthen the national institutions in the target area through regional programmes and activities, and to make available the benefit of network activities to all interested parties, thus helping alleviate the isolation of individual scientists or engineers in the region concerned. According to Forje, three underlying principles that distinguish this approach are:

- the major objective is to strengthen national capability through regional co-operation;
- activities are based on facilities of existing institutions;

- scientists and engineers belong to the participating national or regional bodies of the region and have a high degree of control over the execution of the regional programmes and activities.

Each network normally includes one point-of-contact in each participating country (a national institution or organisation designated as such by the government and other institutions of the country concerned). The point-of-contact is the channel of communication between the network and other institutions, groups and individuals working in the fields of interest of the network in that country. Where appropriate, these national interests may be organised into a national network or other appropriate mechanism. An international organisation or one of the national points of contacts provides the Secretariat. This may be done on a rotating basis if the network secretariat is provided by a non-governmental organisation, although in such cases many of the participating national institutions receive financial support from the respective governments. In such cases non-governmental organisations may provide the secretariat, but governments are always consulted in identifying the national points-of-contact.

Another form of co-operation is the "technological alliance", which is increasingly enterprise driven (both private and public), and is a growing feature among enterprises within the European Union, the United States of America (USA) and Japan. Thus alliances are practised at the national, regional and international levels with a view of maintaining or penetrating distant markets. According to the OECD (Organisation for Economic Co-operation Development in Europe), international strategic alliances in R&D expanded swiftly in the 1980s. In fact, between 1980 and 1990 the total number of scientific and technological alliances grew at an average of 10.8% per year, with about 65% of those alliances involving partners from different countries. Technology-based alliances are especially popular in the fields of information technology, biotechnology and advanced medical material (OECD, 1999). For example, these fields constitute about 25% of intra-European alliances. Generally, sectors for co-operation tend to differ from one industry to another. For instance, at the regional/ international level technological alliance is much more visible in the aerospace industry, which covers 42% of all alliances within the EU (André, Fasella & Ruberti, 1998:87), and is giving the Union an increasing share of the global market in civil aviation aircraft.

1.10 STUDY OUTLINE

The study is divided into eight chapters.

Chapter 1, the present chapter, introduces the study, setting out the purpose and the methodology of the study and providing a background and motivation for it.

Chapter 2 provides the theoretical framework for the study, incorporating both development and institutional theories on S&T. Among the theories in the discussion are modernisation theory, where we revisit WW Rostow's work based on his analysis of the stages of economic growth and development and how S&T is perceived in this process; dependency analysis, comprising structuralists and dependency theorists, is discussed and their views on scientific and technological progress are highlighted. The main theoretical framework, however, is knowledge-based development, which we advocate and regard as relevant, since the knowledge economy is now the talk of most policy makers. But we argue that knowledge-based development should not be limited to information and communications technologies (ICTs), even though this sector is now considered to be the fastest growing in world trade in goods and services. These discussions would be incomplete if the views of the post-developmentalists were not brought to the fore, especially their views on modern science, technology and development.

Chapter 3 reviews the history of science, technology and institutional co-operation in Africa, pointing out four phases, which include the pre-colonial, colonial, national and post-national. The questions of whether Africa has contributed to scientific knowledge, and why most discussions on the socio-economic analysis of science and technology in Africa have neglected the pre-colonial phase, in which indigenous knowledge was important, are investigated. We discuss these phases as well as the institutionalisation and inter-territorial co-operation in the colonial era and also the Africanisation and breakdown of S&T co-operation in the national phase. In the post-national era the privatisation of state-owned enterprises and a liberalisation of the markets has occurred, which has been combined with the commodification of knowledge and knowledge production. Is the state losing its edge, particularly in Africa, and will international and regional institutions be able to fill the gap through co-operation?

In the light of this, Chapter 4 will examine Africa's relations with the World Bank, UNESCO, and the UN Economic Commission for Africa in the development of S&T. In particular, the lending patterns of the World Bank in support for S&T development in Africa. UNESCO's programmes in terms of policies and programmes, including the biotechnology and microbiology programmes, as well as the African Network for Science and Technology Institutions, are among aspects discussed, while the ECA attempts to create techno-regionalism since the late 1970s are considered.

Chapters 5 and 6 evaluate Africa's own institutions, including the African Development Bank (drawing a brief comparison with Inter-American Development Bank), and the Organisation of African Unity at the continental level. We look at the AfDB lending for education for human resource capacity building and its awards for multinational programmes in support of and promoting regional co-operation and integration. The OAU's organisational framework for scientific co-operation and programmes including the Pan-African Rinderpest and nuclear science and technology programmes will be discussed. The sub-regional institutions of the Southern African Development Community (SADC) and the Economic Community of West African States (ECOWAS) and their scientific and technological programmes are also dealt with. As far as SADC is concerned, our discussion is based on the Southern African Centre for Co-operation in Agricultural Research (SACCAR) and its postgraduate training programme, and the SADC Protocol on Education and Training. In relation to ECOWAS, the discussion is based on the inter-regional telecommunications programme and the agricultural development strategy.

In order to compare the development of institutional co-operation in S&T, particularly in other developing regions in the world, Chapter 7 contains an analysis of what lessons Africa can learn from the past and from the experiences of other developing regions, especially from the European Union and the Association of South East Asian Nations.

Finally, Chapter 8 contains a summary of the thesis and recommendations on how the institutional challenges in terms of S&T can be addressed in the twenty-first century in order to enhance the socio-economic development of Africa.

CHAPTER TWO

SCIENCE AND TECHNOLOGY IN THEORIES OF DEVELOPMENT

To keep track of the wide range of explanations that are offered for persistent poverty in developing nations, it helps to keep two extreme views in mind. The fist is based on an object gap: Nations are poor because they lack the valuable objects like factories, roads, and raw materials. The second view invokes an idea gap: Nations are poor because their citizens do not have access to the ideas that are used in industrial nations to generate economic value ... each gap imparts a distinctive thrust to the analysis of development policy. The notion of an object gap highlights saving and accumulation. The notion of an idea gap directs attention to the patterns of interaction and communication between a developing country and the rest of world (Romer, 1993:543-4).

2.1 INTRODUCTION

In the aftermath of the Second World War S&T has revolutionised the patterns of socio-economic transformation and development of many states and societies, particularly in advanced countries. During this same period the underdevelopment of many of the countries in the Third World, which have since gained independence, has been of great concern to social theorists and policy-makers alike. As a result the international community has witnessed the proliferation of both intergovernmental and non-governmental organisations wishing to facilitate development processes in developing countries.

In an effort to formulate policies for developing countries that would address this situation, many development theories have been formulated. The growth of development theories was especially marked in the 1950s and 1960s. Despite different levels of analysis, most of these perspectives on development focus on the following factors: values, motives, attributes, colonialism, imperialism, foreign capital investments, patterns of trade, techniques of management and the production of individuals, organisations and societies, and other characteristics of the international system that are a source of socio-economic development.

These theoretical perspectives have been problematic, particularly with regard to science, technology and development, mainly because of the difficulties scholars have experienced in quantifying the impact of S&T in economic growth and development (National Science Board, 1996:80-89). Another problem is that economists have treated technological change as external factors to the production process since the late nineteenth century. The positive impact of S&T can, however, never be ignored, as is emphasised by the position of the

Organisation for Economic Co-operation and Development (OECD), namely that the "relations between R&D and economic growth are paradoxical in as much as they are both evident and non-measurable" (OEDC, 1968:255). Yet the development challenges have become more complex every day, particularly in developing countries.

Since it is accepted that the extent to which development institutions lend importance to the development of S&T is guided by their particular development paradigm, this chapter reviews the leading development theories in order to analyse what role they afford S&T in the development process. The first two development theories that are discussed are modernisation theory and dependency theory. With their various offshoots, they have dominated the literature on development theory since World War II.

In recent times development issues have centred on knowledge. The theory underpinning these issues has become known as knowledge-based development theory. This theory places great emphasis on the application of modern S&T to every sphere of socio-economic transformation and development, including political and justice systems. The differences between the role of S&T in development in the theories of modernisation and dependency, on the one hand, and of knowledge, on the other, are analysed and critical comments provided. Post-development theory, as a general critique of knowledge-based development, is discussed; scientific and technological development, either through transnational institutional analysis or through an eclectic approach, is also emphasised; and lastly, a tabular summary of the general theoretical discussions is provided.

2.2 MODERNISATION THEORY

2.2.1 Rostow Revisited

Modernisation theorists have an evolutionary perspective on development and define the state of underdevelopment in terms of observable economic, political, social and cultural differences between rich and poor nations. However, modernisation means different things to different people at different times. According to Smith, the concept has been used in at least three senses: as an "attribute of history", as a specific "historical transitional process" and as "development policy" (see Hettne, 1995:50).

Incorporating all these aspects of development, Hettne (1995:50-1) perceives the theoretical assumptions of modernisation theory to be as follows:

- Development is a spontaneous, irreversible process inherent in every society;
- Development implies structural differentiation and functional specialisation;
- The process of development can be divided into distinct stages, showing the level of development achieved by each society;
- Development can be stimulated by external competition or a military threat or by internal measures that support modern sectors or modernise traditional sectors.

Despite these general assumptions, individual scholarly approaches differ considerably. These differences concern the stages of growth, the idea of a dual economy, modernity, institutional reform and classic Marxism. They also concern McClelland's psychological motivation and the need for achievement; Hoselitz's theory on a classless versus a class society; Germani's emphasis on secularisation; and Talcott Parsons's pattern variables (see, for example, Spybey, 1992; Jaffee, 1990; Hulme & Turner, 1990; Kay, 1989; Hunt, 1986). However, generally modernisation theorists seek to identify in the organisation and history of industrial countries those social variables and institutional factors that are crucial for their own development in order to apply them in the facilitation of the development process in newly developing countries (Larrain, 1989:87).

Of all the modernisation theorists the one who has attracted the most attention and has been the most criticised is WW Rostow. His main work, entitled *Stages of Economic growth: a non-communist manifesto* (1960),[1] reflects the essence of modernisation theory clearly. Using European economic history (particularly the British Industrial Revolution) as his starting point, Rostow identifies five stages of economic growth, each enhanced by a certain level of development, which can be used as a framework for national development in any particular context. The stages include the traditional society, the pre-conditions for take-off, the take-off, the drive to maturity and, lastly, the stage of high mass-consumption.

Stage 1

According to Rostow (1960:4) "a traditional society is one whose structure is developed within limited production functions based on pre-Newtonian science and technology, and on pre-Newtonian attitudes towards the physical world". He uses Newton here as a symbol for

[1] From it first print in March 1960 the demand for the book was so great that by August 1968 it had been reprinted seventeen times.

the watershed in history when humanity came to believe widely that the external world was subject to a few knowable laws and was systematically capable of productive manipulation. In this view pre-Newtonian societies include the dynasties in China, the civilisations of the Middle East and the Mediterranean, and medieval Europe. However, Rostow (1960:5) adds to this category those post-Newtonian societies which for a time remained untouched or unmoved by the new capacity for regularly manipulating the environment to their economic advantage.

In a traditional society a great proportion of resources was devoted to agriculture because of the limitation on productivity (Rostow, 1960:4). Rostow believes that the ceiling that existed on the level of attainable output per head resulted from the fact that the potentialities that flow from modern science and technology were either not available or not applied regularly and systematically. Mitelmann and Pasha (1997:60), who perceive the lack of science and technology as the central feature of traditional society, confirm this point of view.

Stage 2

The second stage, the pre-conditions for take-off, embraces societies in the process of transition. Rostow (1960:6) ascribes this stage of development to the effect of the dynamism of the lateral expansion of world markets and international competition on a particular setting. In modern history the pre-conditions do not arise endogenously, therefore, but from some external intrusion from more advanced societies. This is why traditional societies have persisted side by side with modern economic progress by colonial or quasi-colonial power (Rostow, 1960:7).

For the take-off stage to occur, the rate of investment must also improve. According to Rostow (1960: 20), some people in society must be able to manipulate and apply – and in a closed system they must be able to create – modern science and useful cost-reducing inventions. In other words, the transition "requires a radical shift in the society's effective attitude towards fundamental and applied science; toward the initiation of change in production technique; toward the taking of risk; and toward the conditions and methods of work".

In Western Europe this stage was initiated in the late seventeenth and early eighteenth centuries, when the insights of modern science began to be translated into production functions in both agriculture and industry. Because Britain did not only have the natural resources – a leading feature of this stage – but also a particularly appropriate geography and social and political structures that favoured trading possibilities; it was therefore the first to develop the pre-conditions for take-off among the Western European countries.

Rostow (1960:6) emphasises that it takes "time to transform a traditional society in the ways necessary for it to exploit the fruits of modern science, to fend off diminishing returns, and thus to enjoy the blessings and choices opened up by the march of compound interest". In contrast, however, a crucial feature of the second stage is that the economy can stagnate and even slip backwards very easily.

Stage 3

For a developing society to maintain its development, Rostow's third stage of self-sustaining growth is indispensable (Auty, 1995:4). The third stage, take-off, is described as the "great watershed in the life of modern societies". The take-off is the interval when the old block's resistance to steady growth is finally overcome. The forces making for economic progress, which yield limited outbursts and enclaves of modern activity, expand and come to dominate the society. At this stage effective investment may rise to 50% of the national income and savings to 10% or more (Rostow, 1960:8, 20).

The take-off requires the following related conditions (Rostow, 1960:39):

- a rise in the rate of productive investment from 5% or less to over 10% of national income (or net national product (NNP));
- the development of one or more substantial manufacturing sectors, with a high rate of growth;
- the existence or quick emergence of a political, social and institutional framework which exploits the impulses to expansion in the modern sector and the potential external effects of the take-off and gives it an on-going character.

Another feature of the take-off stage is the emergence of an industrial lead sector, such as textiles or steel with strong backward and forward linkages. In the case of the steel industry, for example, a backward linkage could be the establishment of coal and iron ore mines to supply the steel mills. A forward linkage could include factories to process the steel, such as shipyards and engineering works. During the take-off stage such a lead industry triggers the proliferation of new ventures throughout the economy.

According to Rostow, the first-take-off occurred in Britain in the late eighteenth century, followed by France, Germany and the US in the late nineteenth century. In Britain textile manufacture was the lead industry, while in the US railways led the industrial growth and development.

The biggest difficulty in the take-off process is provoked by the greatest advantage: access to modern technology, including medicine. The resulting lower mortality rates and increase in population create problems of chronic unemployment and poverty, which require yet bigger investment and growth rates to avoid a slip backwards (Larrain, 1989:97).

Stage 4

The drive to maturity follows the take-off as the fourth stage. This stage involves the application of modern technology to all sectors of the economy and not just the leading sector (Rostow, 1960:59). Since it is marked by the emergence of new industries, which dominate the economy and sustain the overall growth rate, it requires massive structural change as the majority of the workforce shifts out of low-productivity farming into services and high-productivity manufacturing. These social and demographic changes result in a major redistribution of the population from rural to urban areas.

Rostow suggests that the symbolic dates for technological maturity for some of the advanced countries were 1850 (Great Britain), 1900 (United States), 1910 (Germany and France), 1930 (Sweden), 1940 (Japan), 1950 (Russia and Canada). He notes that in the last quarter of the nineteenth century steel, new ships, chemicals and electricity industries were replacing the old coal, iron and heavy engineering industries as the new centres of growth.

Stage 5

The fifth and final stage, high mass-consumption or post-economic maturity, is reached when all the sectors of the economy – primary, secondary and tertiary – use the most modern technology. As ongoing scientific and technological innovation raises productivity, the per capita income continues to rise. Rostow (1960:73-74) identifies three main transformational activities that use state resources during this stage:

- the national pursuit of external power and influence that usually involves the allocation of increased resources to military and foreign policy;

- the establishment of a welfare state, in which the powers of the state are used to redistribute income through progressive taxation in order to achieve human and social objectives which the free market, in its less adulterated form, has failed to do; and
- the expansion of consumption levels beyond basic food, shelter and clothing into the mass production and consumption of consumer goods and services.

Unlike the previous stages, which Britain often reached first, this level of growth and development, the high mass-consumption stage, was first reached by the US (Rostow, 1960:74).

2.2.2 Critical Analysis

Rostow admitted that defining these stages was not an easy task as science and technology in these societies and their applications were not evenly distributed. Although France was considered to have reached technological maturity by 1910, for example, it still had a technologically backward peasantry at the time. In Canada Quebec lagged behind when the country reached economic maturity in 1950, while the South was backward in the United States until the 1930s. The Japanese agricultural sector was also still labour intensive in 1940 (Rostow, 1960:67-70).

The five stages of development and the assumptions on which Rostow's analysis is based have therefore been widely disputed. The main criticisms concerned his anti-communists bias and the fact that he based his analysis on the experience of only fifteen industrialising countries in the nineteenth century (Auty, 1995:6). Some critics also claim that the model describes political changes, but gives little insight into the mechanism by which economic growth and development occur (Spybey, 1992.) The failure of the idea of a "trickle-down" effect of aggregate gross national product (GNP), a general criticism of modernisation, has also been used against Rostow (see ICSPS, 1992:13-14; Amin, 1974:8).

The reality is that Rostow's stages are often blurred and therefore cannot be separated into watertight compartments. Moreover, in today's advanced societies some activities that can be attributed to traditional societies still prevail. The agricultural sector is still one of the important sectors in the industrialised countries of Western Europe and the US, for example. Even Fox hunting persists in Britain as a sport, although it has become a major political issue.

Notwithstanding the barrage of criticisms against Rostow, however, his theory can be singled out among modernisation theories as the one that has afforded prominence to science and technology. Since it views progress in S&T as one of the main engines of economic growth, industrialisation and development, it accounts for the fact that less land is cultivated, but more food is produced. Except for very few analysts who have highlighted Rostow's emphasis on S&T (Mittelman & Pasha, 1997:60), critics have neglected the significance he accorded scientific and technological progress in socio-economic development. This progress repudiates the assumptions of Thomas Robert Malthus that population growth could outstrip food supply and could only be checked by famine, epidemic diseases and other natural disasters, a view which to this day remains a contentious issue.

Because transformation and progress are not peculiar to the Third World, but are characteristic of advanced countries (Dickson, 1997), the transfer of technology has been central to many developmental issues in both developed or developing countries. According to Agnew (1982:22) discussion of Brown (1981), a market and infrastructure perspective on development will emphasise the important role of technology suppliers and the necessary infrastructure in the process of transfer. An economic history perspective, on the other hand, will focus on the matching of technology to local conditions and the importance of the institutional framework for technological adaptation. Lastly, a development perspective will stress the political-economic context and the negatives rather than the positive consequences of technology transfer.

In this regard Agnew (1982:23) points out, firstly, that modernisation theories "tend to have a more positive view of technology transfer than do the other theories". The creation of the mechanisms for the supply of technology to develop infrastructure and improve the general spread of knowledge about technology is considered to advance development. In the light of this, technology is considered to facilitate economic growth through transfer. Agnew points out, secondly, that since none of the theories of development refers to an economic perspective on technology transfer, writers such as Rosenberg (1970), Hayani (1974) and Saxonhouse (1974) are able to claim that the economic history perspective "has generated the most empirical research on technology transfer and pinpointed the specific barriers to the easy transfer of technology from one setting to another" (see Agnew, 1982:23).

Perhaps the subtitle of Rostow's book, *A non-communist manifesto,* diverted the attention of critics from recognising the centrality of S&T in Rostow's theory in socio-economic development. Whatever the case, it is precisely his attack on communism that prompted dependency theory, which became the "official" development doctrine of most African countries and governments.

2.3 DEPENDENCY THEORY

It is often taken for granted that all dependency theories belong to the Marxist-Leninist tradition. While Lenin's work could be classified as dependency theory, Marx's notion of imperialism is that "the industrially more developed country shows the less developed one an image of its own future" (Marx, 1967:8-9, as quoted in Blomstrom & Hettne, 1984:10; see also Agnew, 1982:20; Roxborough, 1979). In this regard Hettne perceives classic Marxism as more closely related to modernisation theory than to dependency theory. In a similar vein Agnew (1982:19) argues that "... in emphasizing agricultural and technological change as major factors in development", 'classic' Marxism is "remarkably akin to" Rostow's modernisation theory.

The most ardent Marxists, therefore, recognise the value of S&T. Habermas (1971:100) points out that the development from liberal to advanced capitalism has two main characteristics noticeable since the last quarter of the nineteenth century. The state intervenes, firstly, in the relations of production in order to control the dysfunctional aspects of capitalism (i.e. to secure the system's stability) and, secondly, in the forces of production by organising science to generate technology (research and development programmes). That is, there has been "a growing interdependence of research and technology, which has turned the sciences into the leading productive force". Habermas (1971:104-105) calls the latter process the "scientisation of technology" and notes that a perspective is created through which it appears that "the development of the social system seems to be determined by the logic of scientific-technical progress"; in other words, science and technology are causing a social revolution.

The influence of dependency theory originated in the post-World War II era through the formation of the United Nations Economic Commission for Latin America (UNECLA), established in 1947.[2] Its first president was Raul Presbich, an Argentine economist. Later the works of Celso Furtado (1970), Paul Baran's *The Political Economy of Growth* (1957), André Gunder Frank (1966) and Samir Amin's *Accumulation on a World Scale* (1974) spread the

[2] Since the 1980 UNECLA's name has changed to the United Nations Economic Commission for Latin America and the Caribbean (ECLAC).

development, underdevelopment and imperialism thesis. Walter Rodney's work on Africa (1981) had the same effect. Two main strands of the dependency theory on development originated in Latin America: structuralism, which developed as a critique of neo-classical analysis, and dependency analysis and engaged in a critique of modernisation theory (Kay, 1989:2).

2.3.1 Structuralism

The term "structuralism" refers to development perspectives that are critical of free international and internal markets, and that ascribe underdevelopment in the Third World to the international trade of developed countries. However, structuralists examine both the positive and the negative aspects of scientific and technological innovations. According to these perspectives, the marginalisation that has occurred in the South is due to the lack of progress in S&T, which is fundamental to development.

Among the issues tackled by the structuralists are therefore the terms of trade between the centre and the periphery, the process of import-substituting industrialisation and the inflationary phenomena in Latin America. The main advocates of structuralism were the social scientists working for UNECLA, among whom were Prebisch and Singer. These authors were critical of free international and internal markets and of international specialisation, arguing that there is a tendency for the terms of trade in primary commodities to deteriorate at the cost of developing countries. Those who viewed the international system in structural terms argued therefore that in favouring developed countries international trade led to underdevelopment in the Third World.

Attributing underdevelopment to a lack of industrial development, they advocated industrialisation based on inward development strategy, which they argued "provided for the rationalisation of protection, for investment in infrastructure and manufacturing and for planning" (Sunkel, 1977:8). UNECLA became the source of two key terms in the literature of development in the post-World War II era, "centre" and "periphery", which marked a distinction between the industrialised countries of the centre and the primary producing countries of the periphery. The distinction was based on the major difference between the region's access to technology, which determined the production process in relation to international trade.

According to Adler (1987:30), structural critics questioned the appropriateness of Western technology, its prices, the foreign values it implied and the alienation that accompanied it, seeing them as some of the problems caused by dependent development. As a result they believed that development could be useful only if it occurred through "self-determination". This self-determination could be achieved through technical planning, appropriate controls of foreign investment and technology transfer, and constructive development of the indigenous research infrastructure. Since this approach would not require dispensing with the benefits of modern Western technology, the positive aspects of interdependence would remain.

It is the structuralist group of scholars and policy-makers who saw the concept of development and dependency as inextricably linked to scientific and technological development according to Botelho (1997:66). They argued that developing countries were capable of appropriating a significant share of technical progress and could thereby sever their ties of dependence with industrialised and technologically advanced nations if they could make a concerted effort to harness science and technology (Botelho, 1997:66). According to Botelho, they also spurred on the policy formulation of international organisations such as the UNESCO, UNECLA and the Organisation of American States (OAS), in the case of Latin America, to design and implement programmes that would provoke the growth of science and technology in developing countries. The policies projected "the value free nature of science to justify its claim that economic growth, development and social welfare would arise from scientific and technological progress" (Botelho, 1997:66).

In 1950s and 1960s Prebisch supported the structural argument, noting that the unequal exchange in trade between developed and developing countries caused the deterioration of the balance of trade among developing countries for the following reasons:

- Raw material products were subject to substitution by synthetic substances;
- Agricultural products were "demand inelastic", that is, during upswings in prosperity demand for consumer goods increased disproportionately; and
- Technological progress tended to leave primary products behind, especially in terms of earning capacity (see Spybey, 1992:24)

It was such analysis that led UNECLA to propose import-substituting industrialisation (ISI), which has been seen as a failure in most developing countries as compared to export-oriented growth and development strategies.

In the 1970s the idea of self-reliance gained currency among developing countries. Following a Pugwash Symposium in Dar es Salaam in June 1975, self-reliance was conceived in operational terms "to be understood at the national level of each developing country as the will to build up the capacity for autonomous decision-making and implementation on all aspects of the development process, including science and technology. The character, content, direction and pace of social and economic change - whether in rural areas or in urban areas, whether in industries or in education – has to be defined and executed with reference to national needs and aspirations" (Pugwash, 1977:259). The essential components of self-reliant strategy in the field of S&T therefore requires the building up of indigenous capacity to: a) generate and put to use those elements of scientific investigation and technological know-how which autonomous decision-making process has selected for supply from domestic resources; b) identify and acquire, on the best possible terms (financial, institutional and technical), those elements which the decision-making process has identified for foreign supply; and c) blend the two components in such a way that continuous increases in productivity take place (Pugwash, 1977:259). The Pugwash report notes that self-reliant in S&T, as in the development process as a whole calls for the adoption of the principle of "walking on many legs" whether it is in policy-making, programme conception and implementation or institution building. It further places emphasis on the capacity to produce rather on production *per se* (Pugwash, 1977:260). Francisco Sagasti, a long-time proponent of the utilisation of S&T in Third World development, agrees that autonomous development is what leads to an endogenous scientific and technological base that can be used for production. Hence developing countries should aspire to be scientifically and technologically self-reliant (Adler, 1987:48).

In another important development in structural theory, Sagasti divides the world into two interactive civilisations on the basis of their scientific and technological capability. In Sagasti's own words (1980:124),[3] the first civilisation is based on:

- "the growth of science as the main knowledge-generating activity;
- the rapid evolution of science-related technologies;
- the incorporation of these technologies into productive and social processes; and

[3] Ivory Ming (1998), however, considers Sagasti to a transitional theorist, with one foot in the structuralist camp and the other in the dependency camp.

- the emergence of cultural and appreciative forms deeply influenced by the *Weltanschauung* of modern science and science-related technologies".

Sagasti (1980:124) (see also Solomon, Sagasti & Sachs-Jeantet, 1994:21-22) characterises the second civilisation by

- "the lack of a capacity to generate scientific knowledge in large scale and by a passive acceptance of scientific results generated in the first civilisation;
- a technological base that comprises a substantive component of traditional techniques and a veneer of imported techniques;
- a productive system whose modern segment is dependent on the expansion of production in Western industrialised nations and on the absorption of imported technology and whose traditional segment vegetates and is based on an often stagnant traditional technological base; and
- the coexistence of disjointed and even contradictory cultural forms".

Sagasti's first civilisation corresponds to developed or highly industrialised countries, which have an endogenous scientific and technological base, while the second lacks the basic ingredients – in terms of resources, institutions, manpower and cultural background – for benefiting from scientific knowledge and new technological innovations. It is not surprising that he locates these underdeveloped, developing or Third World countries in Africa, Asia and Latin America. Sagasti, who is a former chairman of the United Nations Advisory Committee on Science and Technology, has not only recently re-emphasised the need to bring S&T back onto the international development agenda, but has also made a renewed call for international co-operation with regard to S&T (Sagasti, 1997 & 1999).

In contrast to Sagasti, Jan Annerstedt (1994:116-117) has identified three main dominating regions in the world economy. He uses data from R&D expenditure, innovation and trade patterns in high-tech products as the basis for his analysis. These regions are the East Asian industrial space with Japan at the centre; a North American space with several industrial zones in the US as its core; and the Western European economic space with a number of small but important technologically advanced national economies. Although each of the dominating regions forms a separate supply base for industrial development and production, each is also related to the other two and to other regions of the globe. The regions are therefore related to the international political economy. Annerstedt (1994:117) notes that about a "1000 corporations in these regions control more than half of the world's manufacturing and almost two-thirds of international trade, much of which is in fact intra-regional trade".

Thomas Schott (1998:7) has classified the world into the following eight regions on the basis of their pursuit of S&T:

- North America, comprising the US and Canada;
- Western Europe, comprising Germany, France, Greece, Austria, Belgium, Denmark, Finland, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom;
- Israel, Australia and New Zealand;
- Eastern Europe, comprising the Soviet Union, Czechoslovakia, Albania, Bulgaria, Hungary, Poland, Roman, Yugoslavia, and their successors;
- Eastern Asia, comprising Japan, Hong Kong, Singapore, South Korea, and Taiwan;
- the Rest of Asia, comprising Asia, but excluding Israel and Eastern Asia; and
- Latin America, comprising South and Central America, including Mexico;
- and Africa.

Schott's taxonomy corresponds to geographical patterns rather than with scientific and technological capabilities. However, his treatment of Israel, Australia and New Zealand as a region is based on the assumptions that they are societies "established by European settlers who brought the scientific tradition with them". With this argument he seeks to justify his view that his analysis is based on S&T capability.

More recently, Professor Jeffrey Sachs, the economist at the Harvard Institute for International Development in the USA, has provided a similar analysis of countries in scientific or technological terms. Sachs, for example, structurally divides the world into three: the technological innovators, technological adopters and the technologically excluded. This represents the most recent trends in this line of thinking. According to Sachs, the countries of the first group, which account for only 15 per cent of the world's population, are the technological innovators; the second group, which includes perhaps half of the world's population, is mostly able to adopt these technologies of the first group in production and consumption. Sadly, South Africa and Tunisia are the only countries out of the 53 in Africa that Sachs considers as technological adopters, the rest falling into the third and last category. This group, which covers approximately a third of the world's population and is technologically disconnected is thus "neither innovating at home nor adopting foreign technologies" (see Sachs, 2000:99-101).[4]

In a nutshell, the term "structuralism" refers to development perspectives that are critical of free international and internal markets, and that ascribe underdevelopment in the Third World to the international trade of developed countries. According to these perspectives too, technological progress is fundamental to the development in the South. Kay believes, for example, that structuralism is a direct attack on neoclassical economics.

The question addressed in this study – that is, whether there is a real difference between structural analysis and dependency analysis in terms of the relationship between S&T and development – therefore remains unanswered.

2.3.2 Dependency Analysis

The best known of the dependency analysts is André Gunder Frank, a serious critic of modernisation theory. Unlike his Latin American colleagues, who wrote in Spanish or Portuguese, Frank wrote mostly in English, which afforded him a broader audience than his colleagues were able to obtain (Kay, 1989:9).[5] In his famous work, *The Development of Underdevelopment*, which has been reprinted a number of times since it appeared in 1966, Frank argues that "the now developed countries were never underdeveloped, though they may have been undeveloped" (Frank, 1966:108). He sees underdevelopment as occurring only in metropolis-satellite relations, where the development of the metropolis results in the underdevelopment of the satellite. Since these relations are not limited to the imperial or international level, they penetrate and structure the very economic, political and social relations of the satellites. He therefore perceives the world system as a chain of metropoles and satellites (see Spybey, 1992:24).

[4] See also the analysis by Wagner *et al.* (2000) " Science and Technology Collaboration: Building Capacity in Developing Countries", report prepared for the World Bank.
[5] According to Spybey, David Harrison (1988:81) argues that Frank's work actually popularised dependency theory in Western academic circles (1992:24). Also see Kay (1991).

Frank blames capitalism for the continuous underdevelopment of Latin America since the sixteenth century. He points out that the only times at which development and industrialisation occurred were when problems in the metropoles prevented them from manufacturing for exports. One of his hypotheses is therefore that "the satellites experience their greatest economic development and especially their most classically capitalist industrial development if and when their ties to their metropolis are weakest" (Frank, 1966:112). He refers to five periods in European history to support his theory: the European (specifically the Spanish) Depression in the seventeenth century, the Napoleonic Wars, the First World War, the Depression of the 1930s and the Second World War. The aim of this analysis is to find evidence for his proposition that it is better for underdeveloped countries to sever ties with the developed countries if they are to develop (see Harrison, 1988:96 in Spybey, 1992:26).

African dependency writers tend to support a Frankian type of analysis. They generally argue that Africa was underdeveloped through its incorporation into the world capitalist system (Rodney, 1972), with a result that "autocentric and autodynamic development never became possible" (Amin, 1996:292).

The works of Amin lend further weight to dependency theory, particularly in Africa. Amin's dependency analyses (1974) seek to provide general criteria for constructing an alternative development order within the world capitalist economy. For Amin (1990:66; 1976) the primary criterion for reaching this goal is autocentric accumulation, which is defined as an economic system in which external relations to the world markets are subordinated to the needs of internal capital accumulation/development.[6] Autocentric development supposes a radically different economic, social and political order and has a series of requirements:

- equalisation of income between rural and urban areas and between modern and traditional sectors;
- priority for agriculture;
- control of production by popular organisations and social movements;
- a new role for the state;
- innovations in technology to meet a new demand structure; and

[6] Amin describes capitalism in the centre as *autocentric capitalism*, which requires the existence of a "capacity to produce" and a "capacity to consume", i.e. matching the ability to supply (produce) and the ability to demand (consume).

- significant restrictions to or partial delinking with international markets (see Escobar, 1995).[7]

Since Amin expects obstacles to restructuring through these autocentric measures, he suggests that development can be achieved through new forms of South-South co-operation, including the formation of regional blocs along socialist lines (Amin, 1976 and 1990; see also Escobar, 1995).[8] As he puts it, for delinking to be successful, there must be a "capacity for technological absorption and ingenuity without which the autonomy of decision that has been won cannot be put into effect" (Amin, 1990:60). He adds that "delinking does not imply rejection of all foreign technology, simply for being foreign, in the name of cultural nationalism". Instead, it implies "an awareness that technology is not neutral, either in terms of social relations of production, or in terms of models of living and consumption" (Amin, 1990:67). He realises that, due to the technological backwardness of small and medium countries and the difficulty of producing sophisticated capital goods themselves, importing and exporting is necessary for survival.

In general, therefore, dependency analysis views the relationship between the developed and developing countries as exploitative. This exploitative nature of the system is responsible for the underdevelopment of the South. Because of its technical progress, the North has an advantage in the relationship between North and South. Without such progress industrialisation and development in the South is impossible. Although dependency analysts favour technology transfer to the South, they do so only in so far as it does not hinder endogenous technical growth and development. In contrast, the main proponents of dependency analysis favour a partial delinking of the South and improved South-South co-operation.

[7] According to Amin, there has been a gradual debasement of the meaning of delinking because of its widely usage but the concept of delinking is not synonymous with autarky. That it is the "pursuit of a system of rational criteria for economic options founded on a law on a national basis with popular relevance, independent of such criteria of economic rationality as flow from the dominance of the capitalist law of value operating on a world scale"(1990:62).

[8] For Amin, "the greatness of Kwame Nkrumah and his call for Pan-Africanism, which in his day made some laugh and condemned him to ferocious hatred of others, can now more than ever before be recognised as a clear-sighted awareness of the frailty of a fragmented Africa" (1990:61).

It is on this point that Immanuel Wallerstein's world-system analysis, an offshoot of dependency analysis, differs from dependency theory. Wallerstein views the world economy as one system. Because he believes that capitalism is fluid, he is against delinking developing countries from the world political economy. Employing a systemic analysis, Wallerstein identifies three main development groups: the periphery, semi-periphery and core systemic linkages. In the core area production processes require the highest levels of skills as well as the greatest concentration of capital (Wallerstein, 1974:350). According to Hobden (1998), Wallerstein takes the idea of systemic linkages in the world economy from Arghiri Emmanuel's theory of unequal exchange (1972), which revolves around three main features:

- the highest levels of technology available and accessible to producers in the core;
- the relative mobility of capital as compared to that of labour; and
- the institutional ability of workers in the core to achieve pay increases above subsistence level (Hobden, 1998:147).

Wallerstein's main argument (1980:7-8) is that "the modern world-system took the form of a capitalist world-economy that had its genesis in Europe in the sixteenth century. This involved the transformation of a particular redistributive or tributary mode of production, that of feudal Europe, ... into a qualitatively different social system." He explains that since that time the capitalist world economy has expanded geographically "to cover the entire globe" and has "manifested a cyclical pattern of expansion and contraction (Simiand's phases A and B) and shifting geographical locations of economic roles". He adds that the world has "undergone a process of secular transformation, including technological advance, industrialisation, proletarianisation, and the emergence of structured political resistance to the system itself - a transformation that is still going on today".

Like structuralist and dependency analysts, therefore, Wallerstein considers technological progress as a crucial element in the development of a modern world-system. He notes that "the size of a world economy is a function of the state of technology, and in particular of the possibilities of transport and communication within its bounds. Since this is a constantly changing phenomenon, not always for the better, the boundaries of a world economy are ever fluid". Countries in the core and on the semi-periphery therefore have to fight hard to maintain or improve their status, or they will slip backwards. The fall of the leading capitalist

Spanish and Portuguese nations and the rise of the Asian Tigers exemplify the fluidity of the system.

2.3.3 Critical Analysis

Structuralism

Of course, structuralists argue that putting S&T on the international development agenda is what they have advocated for some time. As Botelho (1997:69) points out, the emergence of STPDD studies predates even science (and technology) policy studies in developed countries. He notes that in the early 1950s the foremost theorists of development, particularly in Latin America, "dialectically identified science and technology both as a historically-shaped structural barrier to development and as a ticket out of underdevelopment". This paralleled the American foreign aid doctrine of Cold War modernisation, which conferred a critical role to S&T, which was perceived as a rationalising social force conducive to democratic politics. For Botelho, modernisation and the embryonic "science, technology and society" and "science policy" movements were therefore "inextricably linked in a complex and paradoxical intellectual and ideological historical web" (Botelho, 1997:69).

Notwithstanding these arguments, structuralists have not been very successful at developing STPDD studies as a full-fledged discipline, perhaps similar to development economics. Admitting this, they tend to blame their failure on external factors. Botelho declares (1997:67), for example, that "STPDD came of age at a time when the political and economic foundations of post-war progress were shaken by the adverse financial consequences of the oil crisis for developing countries and by the concurrent rise of public anti-science and technology movements in many western nations." He explains that the latter undermined the social basis and political support in Western nations for supplying STPDD to developing countries, and the former undercut the demand for STPDD professionals "by undermining the capacity of developing countries to implement STPDD policy recommendations".

Dependency Analysis

One feature of Amin's analysis of particular value to this study is his recognition of the need for technological innovations, even within a socialist system. Despite the fact that his approach has been described as universalistic, however, it is based on a realist epistemology and is therefore similar to modernisation thinking (Escobar, 1995:100).

Dickson (1997) points out that dependency theorists failed to provide an alternative theory of development, a fact that Frank later acknowledges. They did not formulate a new programme that could be implemented once the obstacles to development that they mention have been removed. According to Frank (1981, as quoted in Dickson, 1997:45)

> the usefulness of ... dependence theories of underdevelopment as guides to policy seems to have been undermined by the world crisis of the 1970s. The Achilles heel of these conceptions of dependence has always been the implicit, and sometimes explicit, notion of some sort of independent alternative for the Third World. This theoretical alternative never existed, in fact, certainly not on the non-capitalist path and now apparently not even through socialist revolutions. The new crisis of real world development now renders such partial development and parochial dependence theories and policies invalid and inapplicable.

In the African context a combination of the stages of growth theory of development and market/infrastructure has generally fallen short of expectations. African countries have failed to apply or adopt development theories that seek to promote science and technology as central to the development process of a nation or region. The main problem is that African countries have in reality not practised or maintained the core values of either capitalism or socialism.

General reflection

While both dependency analysts and Wallerstein agree on the importance of science and technology for development, structuralists' views of science, technology and development have been the most visible. Their argument that the oil crisis and the anti-science movements in advanced countries have prevented the implementation of a smooth programme for STDD should, however, not be an excuse for developing countries to stop building their scientific and technological capability for socio-economic development. If they wait for crises to pass, very little development will take place. After the oil crisis of the 1970s, the 1980s were characterised by a debt crisis and economic recession in Western nations. In the early 1990s the Gulf War and the Bosnian War followed. In 1996 the Asian financial meltdown and more recently the war in Kosovo diverted the attention of the developed countries away from developing countries.

Similarly, the recent increases in oil prices (since May 2000) as a result of the decision taken by members of the Organisation of Petroleum Exporting Countries (OPEC) have forced blockades of majors roads and oil refineries around Europe by farmers and truckers (particularly in France, Britain, Belgium, Germany and Spain). To lessen the impact of price increases in the United States, the Clinton administration asked for the release of about 30 million barrels of crude oil from its 571 million strategic oil reserves to serve the American consumers.[9] This means that other global issues are likely to divert financial resources which can support S&T in the Third World away from development assistance.

From our discussion so far it is clear that both modernisation and dependency theorists increasingly accept the critical role of S&T in socio-economic development and transformation, as well as in the politics of a nation. Also important is the fact that in relation to the role of S&T in development structural analysis is not limited to social and economic theories from developing countries, but also stem from advanced countries. The problem that separates the two sides is an ideological one. Since this separation was exacerbated by the politics of the Cold War, the end of the Cold War provides an opportunity for a more meaningful approach to development. This gap seems to have been filled by knowledge-based development.

2.4 THE KNOWLEDGE-BASED DEVELOPMENT (KBD) PARADIGM

2.4.1 Origins

Since the beginning of 1980 and most importantly in the 1990s knowledge-based theory is what has captured the attention and imagination of most policy-makers, academics and politicians, besides globalisation. The development paradigm has also become increasingly knowledge-based, with a result that some states are already conceived as having knowledge-based economies. Fritz Machlup's work, *The Production and Distribution of Knowledge in the United States* (1962), is considered the first modern interpretation of a knowledge society (see Sagasti, 1997).

In a knowledge-based economy S&T has been given an increasingly prominent role in the restructuring and transformation of national and regional economies, as well as in the international political economy. Accordingly, Dale Neef (1998:2) notes that "[t]he basic thesis behind the emergence of a knowledge-based economy is that during the past five years there has been a unique combination of focused market incentives that have led to immense

[9] This was the first time since Iraq's invasion of Kuwait in 1990 that the US drew on its oil reserves. The US action reduced the price of crude by $1,05 from $31, 52 in London (*Business Day* 26 September 2000:1).

technical progress in the areas of computing, biotechnology, telecommunications, and transportation (to name only a few) and which have begun to foster dramatic changes in the way in which economies, organisations, and governments will function in the future".

Neef (1998:1) points out that some scholars describe a knowledge-based economy as one in which the ever-increasing proportion of a nation's GNP is dedicated to computerisation and high-technology electronic industries. For others it is the impetus behind "knowledge management" – the adaptation of traditional organisational structures in a way that better accommodates highly skilled "knowledge workers" who populate the high-performance workplace and provide complex problem-solving services. To preserve their competitiveness, most of the advanced countries and their institutions have already developed policy guidelines for S&T in the twenty-first century.

Mansell and Wehn (1998:257) note that studies from innovation and technological change suggest four relevant insights, which are based on the fact that "knowledge-based development involves learning how to reconfigure existing technological and social capabilities and to restructure institutional arrangement to create incentives for continuous learning". The four insights are:

- success depends on *continuous* investment in both the technological and the social infrastructure;
- organisational change and flexibility go hand-in-hand with new modes and methods of *learning*, which are essential for using new ICT (information and communication technology) applications effectively;
- the capabilities and the use of *tacit knowledge* (or local experience) are as important as the new techniques for accumulating "digital" information; and
- the innovation and diffusion of new technologies like ICTs are never smooth or uninterrupted, but *unpredictable* due to the interaction and occurrence of social, economic and political events (Mansell & Wehn, 1998:257).

On the basis of these insights, Mansell and Wehn (1998:257) define KBD as an "intricate process of weaving together the social and technological component to create a national information infrastructure".

As in the case of all past development theories, KBD contains some critical elements which knowledge-based theorists argue that every nation or region striving to become more advanced should pursue. Sagasti (1980:125) argues, for example, that the emergence of scientific and technological capabilities in the developed countries can only be understood by examining the evolution of ideas that led to science, the successive transformation of productive techniques and the marriage between the two (S&T).

Although there are no comprehensive and generally accepted indicators (OECD, 1996; Steven, 1996), a formula for knowledge-based economic growth and development was developed by Mansell and Wehn (1998:21). The formula or prototype is also a measurement technique, known as the INEXSK (INfrastructure, EXperience and Skills, Knowledge) approach. However, useful as it might be as a checklist for developing countries, the authors limit INEXSK to information and communication technology and exclude other relevant knowledge.

In this regard, the Human Development Report (UNDP, 1999) warns of an overemphasis on information and communication technologies as a panacea to the development problem. The report notes, for example, that e-mail is "no substitute for vaccines, and satellites cannot provide clean water" (UNDP, 1999:59). It cites biotechnology as one of the major areas of focus in the knowledge economy, which fuels the process of globalisation.

Because S&T are not limited to information and communication technologies, the broader term "knowledge-based development" has evolved. Burke (1992) notes, for example, that there are approximately 20 000 major and minor fields of specialisation in S&T (see Nel, 1996:45-46), all of which promote the advancement of knowledge. There is also a difference in the nature of information and of knowledge. Since information is data that have been organised or given structure, that is, it has been placed in a context and thus endowed with meaning, it tells us about the current and past status of some part of the productive system. Knowledge, on the other hand, "allows the making of predictions, causal associations, or prescriptive decisions about what to do" (Bohn, 1998:134).

Furthermore, an important aspect of the knowledge for development discourse is the increased emphasis on international and regional co-operation in science and technology, not only between and among countries but also between firms as well as the growth of the new public-private partnership (PPPs). Thus, there is an increasing dimension of knowledge for development that is transnational in approach. These forms of co-operation are multifaceted in term of sectors of the economy or academic disciplines in areas such as biotechnology applications in the pharmaceuticals and agricultural industries. Moreover, as international competitiveness has become the concern of most regional institutions, the mechanisms for co-operation to harness the human and material resources for sustainable development and competitiveness have been developed or constantly reviewed towards co-operation (see our discussion under EU later in the study; and for increasing trends in co-operation see Gibbons *et al*., 1994; NSB, 1996; OECD, 1999). An example of the transnational approach is the programme in which the World Health Organisation (WHO), the World Bank, the Rockefeller Foundation and the Bill and Melinda Gates Foundation established the Medicines for Malaria programme, with the goal of halving the number of cases of malaria worldwide through the development of new anti-malaria drugs. This programme involves researchers from Monash University in Melbourne, Australia, who will collaborate with scientists from Switzerland and the USA.

Therefore, although Mansell and Wehn's narrow approach can be criticised as limiting, the four factors deserve special attention because of their prominence in KBD. To counter the limitation mentioned, they are discussed in their broader sense in this study.

2.4.2 Mansell and Wehn's formula or prototype of KBD

2.4.2.1 Infrastructure

It has been shown that for modernisation and industrialisation to occur, an appropriate scientific and technological infrastructure has to be developed. As Mudenba (1995) points out, "[t]he advent of the industrial revolution was, in fact, a product of this marriage (between science and technology)". Industrialised countries like the USA, Japan and members of the European Union have developed and continue to design strategies for efficient and effective S&T infrastructure (Mudenba, 1995; Tassey, 1991). The functions of infrastructure and most importantly S&T infrastructure in a nation's development and economic competitiveness have therefore been known for some time.

The Nobel Prize laureate, the late Professor Abdus Salam (1985:302-303), for example, emphasises the following functions:

- the development of scientific literacy through science teaching at all levels, particularly at higher levels, at least for engineers and technologists;

- the training of inspiring teachers;
- the development of well equipped-teaching laboratories;
- the support of local scientific communities;
- encouragement of the interaction between basic and applied science;
- the support of basic scientific research for the riches it might unexpectedly yield for technology.

Salam adds that technology cannot flourish in modern conditions without science. *"[S]cience transfer must (therefore) accompany technology transfer"* (Salam, 1985:309; emphasis in original).

Mudenba (1995) seems to support these views by identifying three specific tasks for the development of an S&T infrastructure at a national, broadly regional and continental level:

- nurturing a community of scientists and engineers;
- strengthening countries with regard to their R&D capability; and
- establishing local engineering consultancies.

More recently, Gregory Tassey (1991:347) has summarised technology infrastructure as including "generic technologies, infratechnologies, technical information, and research and test facilities, as well as less technically explicit areas including information relevant for strategic planning and market development, forums for joint industry-government planning and collaboration and assignment of intellectual property rights". In the early 1980s there was an increasing realisation that technology infrastructure designed for single-stage strategies are inadequate for competitive technology-based economies. As a result, infrastructure and technology-based growth policies were designed to improve the state of scientific and technological infrastructure and to enable both public and private institutions to contribute to the functioning of technology-based economies mostly in the advanced countries. These policy models specify the relationship among institutions that perform the strategic planning, fund or conduct R&D, transfer various elements, and facilitate rapid commercialisation and market penetration (Tassey, 1991:348).

The demand for infrastructure in Africa in the 21st century requires a great deal of commitment from governments in Africa and other donor institutions, both public and private. In a recent symposium entitled "Infrastructure for Africa's Development",[10] Omar Kabbaj, the President of the African Development Bank, noted that African countries need to invest an estimated US$250 billion in the development of infrastructure in the next 10 years in order to bring them to an acceptable level. Such an investment requires an expenditure of between 5 and 6 percent of GDP to upgrade poor infrastructures to encourage investment and economic growth and development (PANA, 24 May 1999).[11] The sectors that Kabbaj mentioned include telecommunications, energy, water and sanitation. The development and the maintenance of such an infrastructure will require a very high level of scientific and technological know-how.

Tassey (1991) confines his analysis to the fact that technology infrastructure consists of science, engineering and technical knowledge available only to private industry. However, we cannot limit technology infrastructure to private industry because development programmes in a country are not carried out by this sector alone. As Tassey himself says, the infrastructure is provided by both public and private institutions, as well as a combination of public-private initiatives.

The question of scientific knowledge as a public good has often led economists to raise the issue of free-riding in the knowledge-generation and application process. To refute the argument that knowledge is freely available and costless to all newcomers, Mowery and Rosenberg argue that it takes research capability to understand, interpret and appraise knowledge that becomes available, whether basic or applied (Mowery & Rosenberg, 1989:15). In other words, knowledge generates knowledge. This shows that developing countries that lack the necessary scientific and technological infrastructure cannot utilise the scientific knowledge, even if it is seen to be freely available.

Mowery and Rosenberg (1989:6) have further pointed out that free-rider benefits have often been a hindrance to the transfer and generation of the scientific knowledge. The transfer and exploitation of technical and scientific information that is necessary for innovation therefore constitute a costly process that is in itself knowledge-intensive. Consequently they emphasise the development of capacity in the process of S&T development.

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[10] The symposium was held at Cairo, Egypt on 24 May 1999.
[11] In the African Development Bank's *African Development Report for 1999*, the main focus was on infrastructure for Africa's development.

2.4.2.2 Skills and Experience

In knowledge-based development activities are therefore concerned primarily with upgrading the capacity and environments of people and organisations to innovate, learn creatively and change. Greater emphasis is therefore placed on the so-called 'soft factor' of production than in traditional production activities, where the emphasis is on the efficient flow and the fabrication of physical products. This is why higher education statistics often illustrate the future potential of a country or region to innovate and adopt modern imported technology and to develop indigenous scientific and technological capabilities.

In this regard Harbison and Myers (1964:15) distinguish two main aspects in which the shortage of high-level manpower disadvantages a country: the generation of skills and the utilisation of skills. They have also developed seven main indicators for measuring of the human resources available to a country. The top three are:

- the number of teachers on first and second level per 10 000 in the population;
- the number of engineers and scientists per 10 000 in the population; and
- the number of physicians and dentists per 10 000 in the population.

The authors also identify two indicators at the higher-level manpower training levels. These are:

- the percentage of students enrolled in scientific and technical faculties in a recent year; and
- the percentage of students in the faculties of humanities, fine arts and law in the same year (Harbison & Myers, 1964:80).

Scientific and technological know-how determines the players and the movers in the global economy. As such, the emphasis on S&T since the early 1980s in advanced countries has been paramount and as a result the national educational policies of various countries are geared towards this development. In their book *Academic Capitalism*, Slaughter and Leslie (1997) studied the trends in the higher educational policies of Australia, Canada, the United Kingdom and the USA. They argue that "[g]lobalisation theories underline the importance of higher education to technoscience, industrial policy, and to intellectual property strategies. Universities are the central producers of technoscience, the primary product of post-industrial economies. At the R&D level faculty and graduate students participate in innovation, increasingly working with industry on government-sponsored technoscience initiatives. Advances in R&D create new fields of knowledge – material science, optical science, electronic communications, biotechnology – which reshape undergraduate education. Universities provide the high-level training, at the undergraduate and graduate levels, essential to technoscience" (Slaughter & Leslie, 1997:39). The implication of this trend is that in the developed countries government funding for social sciences and the humanities has decreased in favour of technoscience, while in the industrial sector, one of the major challenges facing industrial managers is how to produce more innovative products based on the latest science (Branscomb, 1999).

In his book, *Building Wealth*, Thurow (1999:131) presents the significance of skill generation if a nation wants to create wealth. His point of departure is also that skilled manpower or people are needed to discover new knowledge, invent new products and processes, staff the necessary production processes, ensure adequate maintenance of complicated equipment, and even use the new products and processes that advances in knowledge will allow. Citing examples from a World Bank study, Thurow notes that in Japan, 80 per cent of production is held in the form of human skills and knowledge and only 20 per cent in the form of land and natural resources, while in the United States, 60 per cent of its wealth is held in the form of human capital and 40 per cent in the form of land and natural resources. He compares this to nineteenth-century capitalism, when human skills (labour) were rented and therefore a marginal factor of production. In the twentieth century, he argues, capitalism is forced to put human skills and knowledge, rather than machinery, at the heart of the system (Thurow, 1999:132).

Thurow's (1999:135) particular contribution to the KBD debate is his view that a knowledge economy requires two sets of interlocking but different skills: knowledge creation and knowledge deployment. While knowledge creation requires very highly educated creative skills at the top of the range, knowledge deployment requires widespread high-quality skills and education at the middle and the bottom of the range of skills. Using the United States and Germany as his examples, Thurow argues that no single country needs to lead in both forms of knowledge development. In the first half of the twentieth century, he notes, Germany was the leader in the creation of new knowledge, whilst the United States had the highest knowledge deployment. Interestingly, the superior deployment skills of the United States in the middle and lower skill ranges generated higher levels of wealth than did the creation of new knowledge in Germany.

Central to the development of skills is therefore the education system. Formal education has been the first source of skills generation for the modern economy. After the Second World War this emphasis on skills training led to mass education in the developed countries. Although the massification of education took several forms in advanced countries, a clear belief existed that any further economic development was dependent on the availability of educated manpower, especially scientists and engineers (Gibbons *et al.*, 1994:73). In the process new institutions of mass education were created which began to affect institutions of society. The large population of scientists and engineers, for example, spread throughout the economy to take over jobs formerly held by technicians. Large numbers of non-technical graduates were also produced, who transformed jobs formerly held by non-graduates (Gibbons *et al.*, 1994:74).

Stevens (1996:88-90) adds that skilled labour is in high demand in the OECD countries. The average unemployment rate of 10.5% for people with a lower-secondary education falls to 3.8% for those with university education. Although the manufacturing sector is losing jobs across OECD countries, employment is growing in the high-technology, science-based sectors ranging from computers to pharmaceuticals. These jobs are considered highly skilled and pay higher wages than those in the lower technology sectors.

In 1970 the five leading industrialised countries, the United States, Japan, the West Germany, France and Britain, together expended about US$125 billion in constant 1987 terms on R&D. By 1989, the figure had doubled to over US$250 billion, still in constant dollar terms. In 1970 these countries employed about 920,000 scientists and engineers in R&D; by 1989 the figure had almost doubled to 1.8 million (National Science Foundation 1990, as cited in Gibbons *et al.*, 1994:94). A 1988 UNESCO report estimates that in 1970 slightly more than 2.6 million scientists were employed worldwide. By 1990 the number had increased to more than 5.2 million, most of whom were employed in the industrialised and the newly industrialising countries (NICs).

More recently, the World Bank's World Development Indicators has estimated the following averages for scientists and engineers in R&D per million people for 1985-95: Japan (6309), UK (2417), US (3732), Germany (2843), Norway (3678), the Netherlands (2656), Korean Republic (2636), Singapore (2728), South Africa (938), Tunisia (388), Nigeria (15), Egypt

(458) and Rwanda (44) (World Bank, 1999:314-316). It is therefore not surprising that in the developing world scientists and engineers are found mostly in the NICs. In Africa, South Africa emerges as the most advanced S&T country with regard to both the number of scientists and engineers as well the infrastructure. While some African countries, such as Egypt, Tunisia, Kenya, Morocco, Nigeria, Ghana and Zimbabwe may follow in the wake of South Africa, yet others cannot even provide statistical data for comparative analysis.

So serious has been the problem of technological underdevelopment in the Third World as a result of the lack of skills and experience that it has been linked to the policies inherent in colonialism. Colonialism, it is said, "brought education, medical care, and mechanical equipment to the colonies, but did not pass on essential skills and knowledge to the indigenous populations. When former imperial possessions attained political independence, their people and firms lacked the skills and experience to sustain the infrastructure left by the colonial powers or to build on and develop from this base" (Malecki, 1991:20).

There is still a debate as to the level of skills required in production processes. Citing successful examples in various *maquiladora* industries in Mexico, which produce high-quality electronic products and other high-technology consumer goods similar to the NICs in Asia, some commentators argue that fewer skills are needed. Others argue that a contemporary industrial production system requires better educated as well as better-trained persons who are able to understand and carry on with their work in a comprehensive instead of a piecemeal manner. On the basis of such arguments, Gibbons and his colleagues conclude that there is "a new division of labour taking place between high-technology countries and the rest of the world. In the former most complex tasks and highest profits are concentrated, while routine and less expensive jobs are being diverted to the latter. This has been characterised as a new 'industrial divide' between those countries with skilled population and an educational system providing the competencies needed to handle modern equipment and services and others constituting a world of consumers who learn only how to press buttons, and producers of standardised, low-quality goods, whose livelihoods are continuously threatened by the advance of automation" (see Gibbons *et al.*, 1994:131-132).

The above division of labour is precisely the kind of situation that has prevailed in Africa since the early 1960s. Accordingly, Bhagavan (1990:7) notes that from the early 1960s to mid-1980s scientific and technological development in Sub-Saharan Africa in practice entailed only learning how to use technology. Contrary to Latin America and Asia, where there is an emphasis on both the *use* and *production* of technology, African countries therefore have to rely on the services of experts from outside the continent for major routine maintenance or repairs. Given the evidence in recent years that foreign direct investment is now determined by the availability of skills, Africa can be expected to lag behind other emerging knowledge-based economies for some time to come.

To develop and sustain such an infrastructure in developing countries, a community of scientists and engineers is therefore required. This can be created only through the educational system of a country. Demands for an education system that can deal with this need have led to the establishment of national academies of sciences or national councils for scientific research across the world. The Chinese Academy of Sciences has, for example, spearheaded the industrialisation process in China in the South. The establishment of centres of excellence in that country is therefore worthy of note (see Guangzhao, 1996).

The discussion has focused more on skills than on experience. The two are interrelated but experience is gained through practice and permits the adoption of skills that are demanded in the new knowledge economy. Experience was much used in the early period of industrialisation in the training of craftsmen, but Thurow (1999) argues that in the knowledge-based economy, skills are replacing experience. Conservative experience, he argues, can be a drawback to new approaches to the advancement of knowledge.

2.4.2.3 Knowledge

When Francis Bacon said "Knowledge is power" in the seventeenth century, he triggered a debate that is as relevant today as it was then. There is no doubt that every nation or society possesses some form of knowledge no matter how 'primitive' it may be seen to be. However, our concern here is on the form or state of knowledge relevant to production as an important input factor capable of causing not only improved but also sustained economic growth and development.[12] The reality is that science and technology provides this impetus. Nel (1996:49) confirms that in our modern era, which begins from about the seventeenth century, "science and technology have become the dominant determinants of the knowledge structure". This places the colonial era squarely within the knowledge framework.

[12] The recent emphasis on indigenous knowledge seeks to highlight the cultural connotation of scientific knowledge and the fact that every society possesses some form of knowledge that may be relevant to development in other societies and which may be expropriated.

Recent development in the analysis of the concept colonial science has demonstrated the extent to which S&T promoted colonialism. In his book *The Tentacles of Progress: Technology Transfer in the Age of Imperialism 1840-1940*, Headrick (1988) distinguishes five ways in which technology contributed to imperialism in structural terms.

The *first* was the set of important inventions that allowed Europeans to conquer and gain control of inland territories, which they had previously not been able to penetrate. Among these are fire-arms, telegraph, steamships, railways.

The *second* was indirect; that is, the growing demand by the industrialising Western nations for the products of the tropics. This led to free trade, which devastated those territories. The falling costs of transport permitted the shipment of bulky commodities such as cotton and indigo for cloth, palm oil to lubricate machinery, copper and gutta-percha for electric and telegraphic lines, tin for canned goods, and rubber for automobiles. In addition, the affluent demanded increasing amounts of coffee, tea, sugar, cocoa and other tropical goods.

The *third* way in which technology contributed to imperialism, according to Headrick, is the imposition of Western technology on Asia and Africa. In their efforts to increase production and lower production costs Westerners applied industrial and scientific methods to commodity production, which is seen to have restrained traditional technology.

The *fourth* way, an increase in demand for Western manufactured products, was prompted by the introduction into Asia and Africa of "motor vehicles, television, and modern weapons (that had) become irresistible but barely affordable temptations for people of poor countries".

Finally, Headricks argues, nearly all the technological changes that affected relations between the West and the tropics originated from the work of Western scientists and engineers for the benefit of Western society. Their propensity to find substitutes for goods in short supply was remarkable. It included aniline dyes for indigo and other natural colourings, petroleum for palm oil, synthetic rubber for natural rubber, synthetic fibres for silk, beet sugar replaced cane sugar (particularly during the Napoleonic Wars), iron and steel for the teak used in the shipbuilding industries of South Asia, which were ruined as a result. These substitutes seem to serve as the beginning of the revolution in material sciences and biotechnology, discussed below. Whatever the case, Headrick concludes that "[i]n these and other ways, Western scientists and engineers have prevented the demand for tropical products from growing in proportion to the growth in industrial production or tropical population"

(Headrick, 1988:6-8 & 1979; see also Malecki, 1991:19-20).

While Karl Marx is one of the *classical* political economists to introduce scientific and technological progress and the ingenuity of people (Nel, 1996:49; Bhatt, 1980:71) as well as the spread of capitalism (see Cooper, 1973:3) into his analysis of production, Susan Strange's (1988) work on the knowledge structure is one of the most influential in the analysis of the *modern* international political economy. However, between these two scholars, Fritz Machlup is often considered (Sagasti, 1997) to have introduced current knowledge production analysis.

In 1962 Machlup made the first attempt to quantify the growth of the knowledge sector in the post-World War II period. He identified the following five main elements of what he terms "knowledge industries": education, R&D, communications media, information machinery and information services. These elements were used as a kind of typology to measure their contribution to gross national product for the year 1958.

Following his analysis, several attempts have been made (albeit sparingly until the late 1980s and 1990s) to incorporate knowledge directly into the analysis of economic growth and development (see Romer, 1986). The use of the term "knowledge" with reference to a "knowledge society" or a "knowledge economy" has, however, been very contentious. The main question is whether science and technology should be the major indicators of a knowledge structure.

Simon Kuznets (1966:9) notes that "the epochal innovation that distinguishes the modern economic epoch is the extended *application of science* to problems of economic production" (my italics). Daniel Bell (1973:212) confirms this when he views the post-industrial society as a knowledge society on two counts:

- "the sources of innovation are increasingly derivative from research and development (... there is a new relation between science and technology because of the centrality of theoretical knowledge)" and
- "the weight of the society - measured by a larger proportion of Gross National Product and a larger share of employment – is increasingly in the knowledge field" (see also Stehr, 1994:14).

Mathew (1973) also includes science and technology in his analytical framework for the state of knowledge in a country and its relevance to production (Ã). He distinguishes between:

- scientific and technological knowledge (As), and
- other knowledge (An).

This other knowledge (An) includes the principles of accountancy, business administration, personnel management as well as other specific forms of organisational management. Human capital (H) has also been identified in the literature as a unique factor that is different from the labour force (L). Human capital (H), which implies the skills embodied in the labour force (L), reflects the extent to which the labour force (L) is familiar with and capable of using the available stock of knowledge (A) (see Ndebbio, 1992:115-116).

According to Peter Drucker (1993), the attempt to provide the economics of knowledge production in traditional economic theory has failed. This is a result of the failure of traditional economic theory to understand the crucial role of knowledge in production and can be attributed to the lack of a common denominator in different kinds of knowledge. He therefore distinguishes three kinds of knowledge. The first is the continuing *improvement* of process, products and services, which the Japanese call *Kaizen.* Then there is *exploitation*, that is, continuous exploitation of existing knowledge to develop new and different products, processes and services. Lastly, there is genuine *innovation.* Drucker notes that knowledge must be applied in these three ways together and concomitantly to produce change in the economy (see Gibbons *et al.*, 1994:58). This analysis supports three of the four insights identified by Mansell and Wehn: continuous investment, learning and application of tacit knowledge.

One question regarding innovation is whether it is driven by science or by the market. Here opinions are divided among scientists and economists. Hall (1994:22) observes that scientists have traditionally viewed innovation as driven by science and particularly by pure scientific research. He shows that this view was pioneered by the American Scientist, Vannevar Bush in his report *Science, the Endless Frontier* (1945); in which he argued that "[n]ew products and processes are founded on new principles and conceptions which, in turn, are developed by research in the purest realms of science". According to this model, knowledge flows uni-directionally from science to technology and commerce. On account of its predictability, Nathan Rosenberg has described this science-push version of the linear model as dead (see Hall, 1994:22).

The market-driven innovation model, which was pioneered by Schmookler's work *Invention* *and Economic Growth* (1966), holds that market demand determines what applied research is undertaken and what experimental development occurs. Mowery and Rosenberg (1979) criticize the view, arguing that, "the primacy of market demand forces within the innovation process is simply not demonstrated" (cited in Gomulka, 1990:45). More important, however, is the fact that this model is also linear.

In the 1970s competition in the automobile industry from the Japanese coupled with the oil crisis led to a revolution in the industry in the US. A new regulation governing fuel economy was followed with new regulations on safety and emission. Together these factors prompted a re-examination of the whole process by which cars are designed, developed and manufactured, not only to reduce costs, but also to improve quality and reliability. This shows that pull (by demand) and push (by science) are both necessary for socio-economic development (Hall, 1994; Mowery & Rosenberg, 1989:8-9).

As the separation of these approaches is problematic, Kline and Rosenberg (1986) emphasise the importance of *feedback* in a Chain-linked model of innovation. They argue that " in the linear model, there are no feedback paths within the ongoing work of development processes. Nor are there feedbacks from sales figures or from individual users. But all these forms of feedback are essential to evaluation of performance, to formulation of the next steps forward, and to assessment of competitive position" (Kline & Rosenberg, 1986:286). They explain that apart from feeding on science, technological development often stimulates scientific research. During the development of a product new scientific advances may occur when problems are addressed. Kline and Rosenberg (1987:287) also note, for example, the pressures to create new materials is the direct result of feedback on problems encountered in the development of products such as steam turbines, jet engines, semiconductors, solar energy cells and so on (see also Hall, 1994:23-24).

Revolution in material sciences

Thurow (1999) stresses that the materials science revolution allows us to enter a world of designer materials, in which high-value materials are made rather than extracted from the earth. A case in point is optical fibre made from silicon, which has virtually replaced copper in telephone cables. By 1996 more than 60 million miles of fibre had been installed worldwide. At the same time "the number of phone conversations that can be carried has gone from 24 over a digital copper cable to 200 000 on just one optical fibre. In the laboratory it is 20 000 000" (Murphey, 1998:81). The fact that sand is made into silicon wafers and semiconductor chips, kevlar is used to create bullet-proof clothes, while Gore-Tex creates breathable waterproof clothes and lycra is used in almost everything, is also due to advances made in materials sciences (see, for example, Thurow, 1999; Nel, 1996; Forester, 1988; Clark & Field, 1988; Drucker, 1969).

The recent floods in Southern Africa (particularly in Mozambique) during the first quarter of the year 2000 demonstrated the relevance of ICT in helping to bring the sufferings of the poor and those in need to the attention of the international community.[13] They have also demonstrated how advances in transport technologies (air, land and sea) have come to help minimise the suffering of humanity. The recent Asian financial crisis showed how other types of knowledge are crucial for socio-economic development and transformation. The value of ICT in knowledge-based development can therefore not be underestimated.

Advances in medicines and health care systems are equally significant from the material point of view. Murphey (1998) notes that the desire to prolong life and relieve suffering is creating a revolution in "biomaterials", which include artificial tissues and organs made of plastics, ceramics, glass and composites that can augment or totally replace bodily tissues and organs. Thus polyurethanes, silicones, rubbers, carbons and titanium are being used in the cardiovascular system as man-made heart valves, artificial arteries and synthetic blood, while entire artificial hearts are possible in the near future. In fact, a revolution in heart transplants involving the use of "biomaterial" occurred in the Republic of South Africa recently, when a team of cardiologists successfully used an artificial "piggyback" heart known as the AB-180 pump to sustain the life of a patient at a medical hospital in Johannesburg.[14]

The breakthroughs in biotechnology are blurring the boundaries between sectors and creating mega-'life sciences' corporations in the developed countries that are knowledge-intensive

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[13] The 2 June 1999 general elections in South Africa demonstrated the extent to which ICTs can enhance the political process in a country. The Independent Electoral Commission's (IEC) election results centre was equipped with 600 computers and 27 servers and festooned with 2000 telephone lines and 8 kilometres of cabling, which could take up to 3 000 people at a time (*SADC Today*, June 1999:7). The IEC was in a position to give a credible hourly update of the elections to various interested parties.

[14] SABC 3 TV news 20:00 on 28/4/2000. The 50-year-old man's body had rejected a human heart transplant at the Milpark Hospital. The device was attached to the man's circulatory system outside the body. The device takes over most of the work of the patient's heart, boosting blood circulation and allowing the damaged heart a chance to recover by giving the anti-rejection drugs a chance to work (*Cape Times*, 1 May 2000:5). We should also note that South Africa was the country to perform the first successful heart transplant in the 1960s.

(UNDP, 1999:67; Thurow, 1999:178). The discovery of the recombinant DNA[15] (genetic engineering) and monoclonal antibodies through cell fusion (Avramovic, 1996; Murphey, 1998), for example, has provided a new direction in the production of pharmaceuticals, food, chemicals, cosmetics, energy and seeds.

These advances in material and biotechnological sciences have created global competition in international trade. As Europe lagged behind the US and Japan, for example, the European Commission launched the European Research on Advanced Materials (EURAM) programme in 1986 to generate European production capacity that could compete with that of the US and Japan. Other countries have been similarly affected.

In summary, the revolutions in biotechnology, in information and communications technologies, as well as in material sciences, have now resulted in a world where scientific knowledge is constantly re-determining what we can or cannot consume, as well as determining the strengths of national and regional economies in the global political economy. As Slaughter and Leslie (1997:30) put it: "... [p]ost-industrial political economies are fuelled by new advances in science-based knowledge and are powered by computers and telecommunications". However, it is important to note that in a KBD perspective infrastructure, skills, experience and knowledge cannot be isolated in watertight compartments when considering development strategy. They are all interrelated and intertwined and therefore will have to be developed concomitantly, although this will often require strategic choices to be made in particular development programmes or circumstances. This interrelatedness carries far beyond the ITC sectors to include material sciences, biotechnology and other relevant fields of modern science and technology. Notwithstanding the importance of KBD, however, criticism is often raised by post-development theorists against development and modern science and technology. It would therefore be useful for us to look at their views as part of the critical analysis of KBD.

2.5 POST-DEVELOPMENT THEORY AND ITS CRITIQUE OF DEVELOPMENT

Like modernisation theory, which had it strongest critics in the dependency and structuralist

[15] DNA stands for dioxyribonucleic acid. It is the " molecule which carries the genetic information found in all living organisms (with the exception of a few viruses). The information coded by the DNA determines the structure and function of the organism. Every inherited characteristic has its origin somewhere in the code of each individual's DNA" (Avramovic, 1996:xi).

schools of thought, the emergence of post-development theory, particularly since the early 1980s, seeks to serve as a challenge to knowledge-based development (i.e. application of modern S&T to development). Post-development, which is "the mood of postmodernism transposed into development studies" (Nanda, 1999:9), is thus emerging as the greatest critique of development, apart from the old dependency theorists. This group of scholars has in recent times, particularly in the 1990s, been very critical of development policies and programmes as propounded by the developed countries as well as of international institutions for the benefit of the developing and least developed countries.

There are a number of variants of post-development theories, which each seek to criticize development from their own different angle; thus post-development theory is by no means a homogeneous current. According to Nederveen (1998:361), post-development theory tends to show many affinities and to overlap with Western critiques of modernity, Enlightenment and techno-scientific progress, such as critical theory, post-structuralism and ecological movements. At the same time it overlaps with cultural critiques of development and with alternative development.

In a similar vein post-development makes no positive claims and it is associated with several counterpointing views, such as Ivan Ilich's conviviality, indigenous knowledge, cultural diversity and new politics. It shares sensibilities, in particular with alternative development, which began in the late 1960s, especially with the often-cited speech delivered in 1969 by Duddley Seers, the British development economist, and even to some extent with mainstream development. Although post-development differs from the Marxist position, as its focus is no longer on class interests, some scholars such as Escobar reinvokes radical anti-capitalist struggles. Post-development parallels dependency theory in seeking to disengage the local from external dependency, taking it further to development as a power/knowledge regime (Nederveen, 1998:362). Dependency theory, meanwhile, privileges the local, the grassroots. However, Nederveen argues that post-development's faith in the endogenous resembles strands in modernisation and dependency theory – witness the recurrent invocation of self-reliance (Nederveen, 1998:362), although such a view is highly debatable.

Finding alternatives to development has therefore been the major concerns of post-development theorists. For example, Duddley Seers has questioned the rationale behind placing the emphasis too narrowly and focusing only on economic growth as the major determining factor of development in the 1950s and 1960s. He therefore sought to redefine development, as well as the goals of development, to include poverty, unemployment and inequality. According to Seers (1972:24),

> the questions to ask about a country's development are therefore: What has been happening to poverty? What has been happening to unemployment? What has been happening to inequality? If all three have become less severe, then beyond doubt there has been a period of development for the country concerned. If one or two of these central problems have been growing worse, and especially if all three have, it would be strange to call the result "development", even if per capita income has soared.

Yet post-development theorists still strive for a new articulation of great movements: anti-imperialist, anti-capitalist or anti-development and so forth (see Nederveen, 1998:362-363; 2001:6; Martinussen, 1999).

Among the programmes which have come under attack by post-developmentalists is the Four-Point Programme of modernisation principles promoted by President Harry H Truman of the United States in his inaugural speech of 20 January 1949 (see Sachs, 1992; Escobar, 1995; Rist, 1999 [1997]; Esteva & Prakash, 1998). Post-development theorists have also criticised development programmes, both bilateral and multilateral, for their failures and the resulting increase in poverty, hunger and disease and the ever-widening gap between the rich and poor countries of the world. An example of this is the various "development decades" – and their programme failures - launched by the United Nations, in particular the World Bank and its structural adjustment programme in Africa. As a result, Wolfgang Sachs (1992:1) wrote that the age of development, which began in 1949, was coming to an end and therefore "the time is ripe to write its obituary". Post-development, therefore, seeks the transformation of development and development discourse (see, for example, Crush, 1995 [ed.]; Thompson & Tapscott, 2000).

So what have been the views of post-development theorists on modern science and technology?

2.5.1 Post-development critique of S&T

The general critique of development aside, what is of interest to this study, as far the views of the post-development theorists are concerned, is their attack on, or analysis of, modern science and technology and its role in socio-economic transformation and development. In fact, the prospects for the application of science and technology for development, as advocated in our discussion of the knowledge-based development theory, are challenged by some post-developmentalists. As we have already mentioned, their "main article of faith is that modern science and technology bring about alien conceptual categories that are injurious to poor people in the Third World and their local knowledge" (Nanda, 1999:7). For instance, Claude Alvares (1992a:219) argues, "I was born into a culture that continues to exercise greater influence and power over behaviour than modern science does, or will ever do. If *that* were properly understood, then this obituary would not appear either scandalous or scurrilous. Every culture enjoins its members' respect for certain entities. Modern science does not find a place in our pantheon".

Furthermore, some of the post-development theorists who criticise scientific and technological progress stress that local knowledge is suppressed through the imposition of alien conceptual schemes of modern science, technology and economics (Connelly *et al*., 1995:27 cited in Nanda, 1999). Post-development theorists also make an association with modern science as embodying traits of violence, patriarchy and imperialism, which presents a dilemma. As Nanda (999:15) argues some of the theorists raise the issue that imperialism determines modern science and technology and that it serves as the main barrier to genuine scientific and sustainable development. For some post-development theorists modern science and technology have been detrimental to the development of indigenous knowledge which, of course, is a genuine concern (see Alvares, 1980 & 1992b). However, the argument that there is a glorification of modern science (in this case Western science) simply because development has ignored grassroots initiatives and capabilities, leaves much to be desired.

In fact, post-development theorists are very quick to point out the devastating effects of modern S&T on society and the environment. Principal among these negative impacts are nuclear disasters (e.g. Chernobyl) and weapons of mass destruction (both biological and chemical), which are a constant threat to the very existence of that same humanity whose course modern S&T is seeking to advance. According to Sachs (1992:2), "for more than a century, technology carried the promise of redeeming the human condition from sweat, toil and tears. Today, especially in the rich countries, it is everybody's best kept secret that this hope is nothing other than a flight of fancy".

Commenting on the ever-increasing socio-economic gap between the rich North and the poor South, even though the latter is working hard to close or minimise the gap, Sachs attributes this to the application of the most advanced technology. Yet he continues to argue that it is a sign of continuous degradation and that the North is only the "world champion in competitive obsolescence" and therefore decades of smoke-stack industrialisation (Sachs, 1992:3, 28). For Sachs the belief in technology and science has led, and will increasingly lead, to ecological disasters (see Schuurman, 2000:10). The implication of Sachs' argument is that even though the North may be scientifically and technologically advanced, this is an example the South should not be envious of at all. Trying to emulate or replicate their development experiences is not worth pursuing, since these advancements are recipes for ecological disaster in the developing world.

In criticising the modern state and its pursuit of science and technology for development, Alvares (1992b:68-69) further writes:

> … the intimate connection between development and modern science was underwritten by the modern state. The state's commitment to development stemmed from its equal commitment to modern science. Modern science was the ideal choice since it remakes reality by re-creating concepts and laws. It manufactures and produces new knowledge, and fresh interpretations for how things should work. A state which saw itself as a factory, obsessed with "production", found in science a congenial mate to play out its self-appointed role. The modern state does not understand the right of the people to be undeveloped. It claims the right to develop people and nature on the basis of a vision of progress set out according to blueprints supplied by modern science. People have no role other than as participants in this great adventure. In exchange, they are privileged to consume the technological wonders that result from the heady union of development and modern science. In the eyes of the state, that is adequate compensation for a surrender of their rights.
>
> The modern Indian State is a prime example of such trends. It has rigorously adhered to this mode of development in every area of human endeavour – whether it is in producing sugar in preference to *gur*, furthering agriculture based on chemicals rather than organic inputs, expanding a capital-intensive white revolution, elaborating a nuclear energy programme, or the making of textiles on rotary machines instead of on handlooms … development has meant nothing more and nothing less than the outright displacement of one set of ideas, people, realities, cultures and processes and their substitution with another set designed by MS.

Again, the above argument also suggests that modern science, which is often equated with Western science and civilisation, should not be promoted in developing countries. In fact, Alvares (1992a:219-220) calls modern science "an epoch-specific, ethnic (Western) and culture-specific (culturally *entombed*) project, one that is a politically directed, artificially induced stream of consciousness, invading and distorting, and often attempting to take over, the larger, more stable canvas of human perceptions and experiences." Gilbert Rist dismisses scientific realism and claims that Western beliefs in science and development are merely updated myths (Rist, 1997:3, 22). Furthermore, in arguing that the modern era is coming to end, Esteva and Prakash (1998:1-2) re-emphasise that "from their think tanks and ivory towers, deconstructing the castle of modern certainties, post-modern thinkers are slaying the modern dragons: science and technology, objectivity and rationality; global subjugation by one culture – the 'culture of progress' spread across the world through the white man's weapons of domination and subjugation". Similarly, their arguments reflect some of the general views of the post-development theorists' attack on development in general and S&T in particular.

However, Nanda (1999:7) observes that many of the struggles of the poor people of the Third World can be understood in their struggle for better access to modern knowledge and technology. Similarly, Richard Peet (1999:159) argues that such criticism of modern science and technology as propounded by post-development denies the Third World what the First World already has. We must also take note that many of the critics of modern science and development live in the luxurious centres of Western modernity (e.g. Paris, New York, Geneva), or in the major cities and capitals of the South, and enjoy their benefits while arguing that the Third World people do not need them. All those theorists who see only the negative impact of S&T travel by air or road to the countries or regions of their research, using modern means of transport, not by walking. There is a valid challenge to science, as its sub-disciplines have increased greatly.

However, the positive impact of modern science and technology far outweighs its negative consequences on human development. Acknowledging that S&T now permeates every aspect of our human life, Anthony Giddens in his book *The Third Way*, argues "for better or for worse, science and technology have invaded the human body, and have redrawn the boundary between what can be humanly achieved and what we simply have to 'accept' from nature" (Giddens, 1998:58). This is due to the fact that, besides the disasters caused by human failures in the applications of S&T, some natural occurrences are still beyond the control of science: earthquakes, for example, which in the recent past have cost thousands of human lives and caused suffering for many people in Turkey (1999), Taiwan (2000), El Salavador (2001) and India (2001), and the volcanic eruption in Goma (2002),[16] to name a few. There have been floods in Mozambique (2000) and elsewhere as well as hurricanes. Diseases such as malaria, trypanosomiasis, Onchocerciasis and the Acquired Immune Deficiency Syndrome

[16] In the volcanic eruption of Mount Nyiragongo in Goma, the Democratic Republic of the Congo, the lava covered more than 30% of its residential areas and consumed 90% of the business district *(Cape Times*, 25/1/2002, p. 2).

(AIDS) pandemic still do not have any appropriate scientific and medical cures. Giddens continues his argument by stating that "decision-making in these contexts cannot be left to 'experts' alone but has to involve politicians and citizens ... science and technology cannot stay outside the democratic processes. Experts cannot always be relied upon automatically to know what is good for us, nor can they always provide us with unambiguous truths; they should be called upon to justify their conclusions and policies in the face of public scrutiny" (Giddens, 1998:59). As a result, since the end of World War II S&T development and applications have been accompanied by science and technology governance for the betterment of human society due to the concerns of national governments or international institutions as well as non-governmental organisations (Haas, 1975; Ruggie, 1975; Skolnikoff, 1993; see also De la Mothe, 2001). It is, therefore, appropriate for us to consider the negative impact of modern science and technology on socio-economic development and transformation but not to overemphasise them, since the benefits outweigh the negative impact. The irony is that sometimes those who have benefited most from the fruits of modern science and technology are also those who are the severest critics.

2.6 INSTITUTIONAL DEVELOPMENT OF S&T: FINDING THE MIDDLE GROUND

Africa does not possess, even comparatively, the capacity in S&T that Europe, North America and other developed countries or regions have. Since colonial and through post-colonial times agriculture and mineral resources have remained the backbone of the various economies in Africa. Due to the lack of scientific and technical progress such production as was started has often stagnated or even deteriorated. The agricultural revolution, consisting of a shift in cultivation from rain-fed perennial farming and traditional irrigated farming, to quick-return scientific (green revolution) and industrial scientific farming (Auty, 1995:52-3), which transformed Western agriculture through the increased use of land, also bypassed Africa. Neither has the revolution in scientific knowledge that transformed and increased production in other developing countries ever been felt in Africa. Instead Africa has yet to witness a system of agriculture which will provide a sufficiency of food.

Since Africa lacks the critical mass in S&T (other problems aside) to fight hunger, poverty and disease, it should be accorded a high priority by any development institution. Developing countries need to deepen their capability, knowledge and understanding of advanced science and scientific research and to adopt advanced technology in at least key areas, which can then function as leverage sectors to increase productivity in the social sector as a whole.

Underlying the need for science and technology in socio-economic transformation is the need for making strategic decisions on training and the deployment of scarce human and material resources. Three decades ago, Peter Drucker related the dilemma then facing the developed countries in his book *The Age of Discontinuity*. He notes that "the industrially developed countries do indeed face basic questions as to the direction of science and technology. It is not a question of whether scientific and technological change is wanted but the question of where very scarce human resources should be employed to get the best results from knowledge efforts. The debate will be over priorities rather than over the desirability of scientific and technological advance – over where the greatest results are, rather than whether we want results" (Drucker, 1969:70).

Information technology has an over-arching impact as it extends from the most abstract concepts in artificial intelligence, that is, from fundamental ideas of mind and logic to routine skills for the day-to-day use of computers. In a knowledge-based development approach information systems such as general and technical libraries and documentation centres, and communication systems are important for the dissemination of S&T innovations, and are therefore a vital element of the S&T infrastructure. Consequently, Drucker's remark reflects the mammoth task that faces developing countries and international institutions that seek to promote socio-economic development.

The multilateral and bilateral institutions that offer programmes and projects would usually subscribe to a specific development paradigm. However, since the actions of the multilateral institutions are a measure of collective response, John Ruggie (1975:569) argues that the "collective response" of states to collective situations is occasioned by science and technology, and he indicates three levels of institutionalisation:

- the purely cognitive, representing the epistemic communities;
- that which consist of sets of mutual expectations, generally agreed-to-rules, regulations and plans, in accordance with which organisational energies and financial commitments are allocated, which he calls international regimes; and
- international organisation.[17]

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[17] For related discussion see Ernst Haas (1975).

However, since all the development theories which have been discussed above – modernisation, structuralism, dependency analyses and knowledge-based development – recognise the need for the creation of institutional mechanisms for the promotion of co-operation and development, the institutionalisation process cannot be without any theoretical influence at any of the three levels of collective response. Botelho (1999) describes how, for example, structuralist thinking influenced UNESCO policies and the institutional framework of United Nations Economic Commission for Latin America and the Caribbean (UNECLA) in the l950s and 1960s in putting S&T on its programme agenda. Because of the co-operation agreement between the World Bank and UNESCO, the Bank's policies were also influenced by structural analyses at the time.

Furthermore, influenced by modernisation and a neoliberal paradigm, the World Bank itself later realised that science and technology could not be divorced from the development discourse. During the presidency of Robert McNamara in the 1970s, this realisation led to the creation of a Unit of Science and Technology. In its 1998 World Development report the World Bank devoted its attention to knowledge for development, particularly the role of information and communication technology in socio-economic transformation and development. Hence the argument by Nederveen (2001:8) that development thinking plays a fundamental role in agenda setting, mobilisation and coalition building.

The Economic Commission for Africa (ECA) was the first to organise a regional conference on science and technology in Africa in the 1990s, following the lead of UNESCO in the 1970s and 1980s. The OAU has recognised the crucial role of science and technology for development since its establishment. As stated in the 1991 Abuja Treaty, the African Development Bank (AfDB) also aims to promote S&T, in conjunction with the OAU and ECA. The sub-regional institutions (SADC and ECOWAS) are also said to be promoting scientific and technological co-operation and development, particularly in the agricultural sectors in their respective sub-regions and in the African continent as a whole. These institutions, however, seem to promote structuralism.

Other institutions serving the interests of developing countries have been influenced by structuralism and dependency analyses. At its first Summit in 1961 the Non-Aligned Movement (NAM) recognised the important role of S&T and "demanded that the fruits of scientific and technological revolution be applied in all fields of economic development to hasten the achievement of international social justice" (quoted by Chhabra, 1996). Likewise the Group of Seventy-seven developing countries (G-77) called for a new international technology order in the early 1970s to complement that of the new international economic order (Clarke, 1985). These demands had little success and generally failed to develop Third World institutions and organisations until 1989, when the Centre for Science and Technology of the Non-Aligned and Other Developing Countries was established in India and, more recently, the NAM South Centre for Technical Co-operation among Developing Countries in Jakarta. The formation of the United Nations Conference for Trade and Development (UNCTAD) in 1964 is another case in point. Its activities, such as the Draft for an International Code of Conduct for Technology Transfer, however, are yet to achieve their objectives.

The establishment of the Third World Academy of Sciences (TWAS) in 1983 by proven individual scientists from the South, who realised that a nation's competitiveness is reflected in its level of scientific and technological development, pulled together human and material resources. Ever since its formation TWAS has been instrumental in the formation of other organisations and the running of programmes to foster collective self-reliance in S&T among developing countries. This has all taken place within a structuralist paradigm and from the position of epistemic community action, and take into account the role of non-governmental organisations in helping to shape the policy debate on S&T.

The South Commission Report (1990) is a structuralist landmark in the evolution of concerted development efforts by the South. It paid particular attention to S&T. The Report (1990:109) noted that "efficient use of scientific and technological advances is essential for the economic development and social progress of the South. The absorption of knowledge-intensive techniques and the more efficient use of raw materials, energy and labour are indispensable for increasing productivity and international competitiveness and thus for the success of economic adjustment and restructuring in the South". The Commission therefore pinpointed the need for the South to develop a strategy for scientific co-operation that would focus on issues of major concern in which research and innovation could offer tangible benefits through the pooling of resources (1990:209). The report further emphasised the need to foster joint research and development in key areas of high technology such as biotechnology, informatics and material science. Perhaps the most important initiative in this direction was the call for the identification of institutions of the South with high levels of research and facilities for training scientists, engineers and technicians from South countries under programmes of co-operation (Teng-Zeng, 1999).

In furthering this, the establishment of G-15 in 1989 added another impetus to increasing co-operation among developing countries in S&T. It declared its commitment to the concept of collective self-reliance and structural analysis at the First Summit in 1990.

- It was agreed in principle to establish a South Investment, Trade and Technology Data Exchange Centre (SITTDEC) that would promote and disseminate information on investment and trade opportunities in the South and on technology and the transfer of technology among developing countries.
- To stimulate South-South co-operation among the business community and Government, it was agreed that a business and investment forum would be organised to bring together businessmen and investors as well as government officials, to exchange ideas and information on the promotion of and co-operation in South-South trade and investment, including the organisation of trade fairs and the promotion of trade and investment opportunities in the South.
- In the light of the need of the developing countries to further improve their capacity in science and technology, to enhance the capability in food-deficit countries and to cope with the population problem, the specific project proposals in these areas were directed to expert groups for implementation.

Before the Third Summit in 1992 the SITTDEC database project was established with over 7000 documents. SITTDEC is open to all developing countries. The Group also runs five solar energy projects in seeking an alternative source of energy. These projects include solar lighting, solar refrigeration, solar water heating, solar drying and a data bank (Teng-Zeng, 1999).

In practice development theories and institutional policies have a kind of relationship and, depending on the political or economic settings, they may exert considerable mutual influence in two ways. Firstly, structuralist thinking in the 1960s influenced the formation of the United Nations Conference on Trade and Development (UNCTAD) and, since its formation, UNCTAD has been one of the UN agencies that propagates and sustains structural analysis, with science and technology on its development agenda relating to and reflecting the wishes of most developing countries. On the other hand, a well-established institution could promote the ideas, norms and assumptions of a particular development paradigm. For example in the 1980s, the United States and Great Britain withdrew from UNESCO due to the structuralist purview of its policies. In the end the composition of the members of a particular institution and the power relations within it will also determine the kind of theoretical perspectives pursued. In essence, however, developing countries tend to support international regimes or institutions that would consistently endorse those principles and norms which seek to legitimise the authoritative, as opposed to market-oriented, modes of the allocation of resources (Krasner, 1985:5).

Since development entails different multi-level negotiations and struggle among different stakeholders in the development process with different methodogical and theoretical perspectives, it is important to adopt a multi-pronged approach. Adopting a neoliberal and or a dependency approach to development policy and implementation will often create problems because of the clash of ideas. A common solution therefore is for these international and regional institutions to apply knowledge-based development theory where differences may not be too great in terms of the ideas, rules and norms governing the international supply and demand for scientific and technological resources for a common humanity.

Furthermore, while advocating a knowledge-based development, we still believe that it is important for international and regional institutions promoting science and technology for development to adopt an "eclectic mixture of analytic methods and theoretical perspectives" *a la* Gilpin (1987:9; see also Murphy & Tooze *et al.,* 1991). Such approaches are needed to bring to the fore the useful insights of other theoretical perspectives to complement those of KDB, especially post-development perspectives. Thus a combination of KBD and the useful insights of post-development theorists interest in the question of indigenous knowledge for development will enhance knowledge sharing and therefore general societal development. Already the World Health Organisation (WHO), for instance, has a programme in traditional medicine that seeks to encourage and train healers in modern techniques, rather than destroying their local credibility or replacing them with a medical elite from the city (Ming, 1998). Recently, the Kenyan Government announced that it is in the process of finalising a bill to be passed into legislation which seeks to make herbal medicine available in public health institutions in the country. Supporting the government's plan, the WHO Africa regional director, Ebrahim Samba, urged African doctors to stop dismissing herbal medicine since about 80 per cent of most conventional medicines were derived from herbs. Samba went on to state that his organisation was "testing the efficacy and toxicity of two herbal drugs which had proved effective in treating opportunistic infections associated with HIV/AIDS".[18]

Similarly, the World Bank is now adopting programmes in indigenous knowledge, thus buttressing our argument that an eclectic theoretical perspectives is needed to promote S&T for development. In May 2001, for example, the Bank's IK Programme sponsored a seminar which brought together development practitioners from East Africa, scientists from the United States National Institutes of Health, George Washington University Hospital and the Bank staff. The focus of the meeting was on learning from traditional health practices in Africa. The main outcome of the seminar was "an agreement between the participants to work together on validating herbal treatments of HIV/AIDS-related opportunistic infections".[19] The government of South Africa is also promoting the development and applications of IK and has passed legislation to that effect. The adoption of an eclectic approach should also encourage the transnational dimension of S&T co-operation, where the private sector (both profit and non-profit) organisations can also contribute to the building of S&T for development in Africa, and similar developing areas. Table 2.1 below gives a brief summary of the main assumptions of the theoretical discussion.

2.7 GENERAL CONCLUSION

This chapter has examined the extent to which development theories explain the role of S&T in the socio-economic development and the transformation of developing countries. Our argument is that any development theory, whether neoclassical, Marxist, neo-Marxist, or any other does in fact recognise the importance of science and technology in the development process. However, the way in which policy-makers and implementation bodies encourage the pursuit of S&T is influenced by the particular development ideology they espouse. Since ideology determines strategy, political differences over the years have influenced the kinds of technology that developed countries have transferred to their developing counterparts.

However, the main conclusion of this chapter is that none of the theoretical frameworks is adequate to address the development problems confronting the South. Although we advocate KBD whereby the appropriate infrastructure, skills and experience, and knowledge are needed, structural analyses will be required to help identify the structural imbalances between

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[18] *The Nation* "WHO Supports Health Plan On Use of Traditional Medicine" http://allafrica.com 1 February 2002.

[19] "Learning from local communities: how can we learn from healers and farmers? http://www.worldbank.org/afr/ik/bb_51501.htm.

developed and developing countries or even within a developing region. The importance of KBD is that it brings knowledge to the forefront of the development debate. Developing the appropriate science and technology, both human and material, as well as choosing the relevant fields and programmes in the interests of the development of Africa, will be some of the major challenges ahead. Therefore, eclectic methodological and theoretical approaches are needed. As the conduits through which resources are allocated to developing countries international institutions, both governmental and non-governmental, have crucial roles to play in this debate. Africa's regional institutions have also to ensure that the appropriate organisational frameworks are in place, with the necessary programmes for implementation. These institutions (both international and regional) and their programmes are therefore discussed in the rest of the study.

TABLE 2.1: Development theories and their assumptions about science and technology

Assumptions	Modernisation	Structuralism	Dependency	Knowledge-based development	Post-development
Role of science and technology	S&T and cultural values responsible for economic growth and development	S&T central to development; link between knowledge and production	S&T denotes global power relations	S&T major factors responsible for economic growth and development	Modern science responsible for underdevelopment of local knowledge
Initial conditions in developing countries for development	Lack of scientific and technological capability; traditional values as barrier to development and innovations	International trade and price distortions favour developed countries; marginalisation of science in the South	Inequalities in global power reflects the differences between North and South based on S&T; dependence of the South; emphasis centre-periphery relations	Knowledge as a factor of production; lack of S&T infrastructure, skills and experience as causes for underdevelopment	Local knowledge effective for self development and sustainability but has been suppressed by modern science
Technology transfer	Over emphasise the positive aspect of technology transfer	Emphasises both the positive and negative aspects of technology transfer	Over-emphasise the negative aspect of technology transfer	Importance of technology transfer and knowledge networks	Legitimise and modernise indigenous knowledge
S&T policy options	Technology transfer to the south, reform of traditional values, increased investment, promote market forces in the demand and supply of S&T	Indigenous S&T capacity, import-substituting industrialization, transfer of appropriate technology, joint investment in the south, favour interdependence and scientific interaction, North-South and South-South	Partial de-linking from the North, improve south-south co-operation; self-reliance, appropriate technology, social transformation	Increased scientific research, innovations, education and training policies, public–private partnerships, link between scientists and industry, scientific co-operation and technological alliances	Promote indigenous knowledge and traditional values
Epistemology	Universal science	Universal science	Increased local knowledge	Universal science	New approaches to knowledge generation are needed and not necessarily universal.
Co-operation	State-centred	State-centred and multilateral approach	State-oriented endogenism	multilateral and regional approach including public-private partnership (transnational approach)	endogenous (local and regional) approach

CHAPTER THREE

THE HISTORY OF SCIENCE, TECHNOLOGY, AND INSTITUTIONAL CO-OPERATION IN AFRICA

3.1 INTRODUCTION

In Chapter 2 we emphasised that historically all the development theories recognise the important role of science and technology in development. We also noted that every society possesses some form of knowledge, no matter how primitive it may seem to be. Moreover, the growing importance of indigenous knowledge and its preservation lends credence to the relevance of knowledge in all human civilisations. Although Africa is reputed to be one of the cradles of human civilisation, the present state of socio-economic development and the recent past history of colonialism in Africa have precluded efforts aimed at scientific and technological development from being realised. Nonetheless, since S&T has been seen to form an integral part of economic and social transformation in the annals of development discourses, this chapter makes an attempt to trace the historical development of S&T in Africa. Both national and regional as well as international efforts are of particularly great importance to our understanding of the history of S&T in Africa; this chapter, however, devotes much attention to efforts aimed at scientific and technological co-operation in the various stages of S&T development.

3.2 PHASES OF S&T DEVELOPMENT AND MANAGEMENT IN AFRICA

Nel and Teng-Zeng (1999) argue that recent steps towards a deeper and perhaps more sustained attempt at international co-operation in S&T on the African continent form part of a broader pattern of change in what can be called scientific development and management. Similarly, as can also be detected in other parts of the developing world (e.g. Latin America), the evolution of S&T in Africa has gone through a number of phases. Expanding somewhat on the useful but somewhat restricted analyses of Gaillard, Krishna and Waast (1997), who identify three modes of scientific development and institutionalisation: colonial, national and private; Davis (1982) and Gruhn (1967), Nel and Teng-Zeng (1999) identify at least four phases of scientific and technological development in Africa: a pre-colonial phase characterised by traditional S&T, a colonial phase dominated by European scientific organisation; a national phase characterised by the reorganisation of S&T within the newly independent states and the collapse of the inter-territorial institutions; and a post-national phase characterised by the renewed interest in a regional and international orientation towards the development of S&T.

3.2.1 Pre-colonial Science and Technology

The first and still most uncharted stage is the *pre-colonial* phase, which was characterised by a range of knowledge activities, ranging from the informal to the formal, and a near absence of attempts to deliberately manage the production, storage and dissemination of knowledge (Nel & Teng-Zeng, 1999). Africa's pre-colonial scientific development, although occasionally impressive, was very unevenly distributed. Technologies in agriculture, astronomy, metallurgy and mining were widely dispersed both in time and space. Yet much of the scientific writing, and therefore Africa's contribution to world science, has been neglected, while some scholars like Gruhn (1984:2) argue that there was "little pre-colonial science, in spite of fairly advanced numerological and other speculative activities". However, we dispute such a notion, because there was some level of scientific and technological advancement within individual communities, no matter how rudimentary or advanced they might have been.

For example, this technological sophistication includes the discovery of iron ore technology in Kenya around Lake Turkana and an astronomical observatory among the Dogon of Mali. Through archaeological excavations and analysis of 13 Iron Age furnaces by the American scientists Schmidt and Avery in East Africa in 1978, it has been established that an iron-smelting process was developed in Africa between 1500 and 2000 years ago. Africans (Huya) living on the western shores of Lake Victoria in Tanzania produced carbon steel. This process of technological development was much more sophisticated than any developed in Europe before the mid-nineteenth century. Explaining the possible decline of productivity, they argue that it may be linked to an over-exploited forest resource base, and that the evolution of a fuel-efficient preheated furnace may be an adaptation by the local smelters to this depleted resource. They further argue that "[t]he enormous drop in productivity since the first colonial government in 1840 is attributed by the smelters to the availability of cheap, imported iron tools and spring steel and to the greater rewards of coffee farming" (Schimdt & Avery, 1978:1089; see also van Sertima, 1999:307-308). This knowledge, according to Schimdt and Avery, will help to change scholarly and widely believed ideas that technological sophistication developed in Europe but not Africa. For them, the ramifications of their findings are of great significance for the history of Africa and her people.

Besides the West Lake Region, other areas in Sub-Saharan Africa where the technology of iron metallurgy has been found include Daboya (9"31' N, 1"22' W), along the White Volta River in northern Ghana; Taruga (9"05' N, 7"10' W), in central Nigeria; as well as in Meroe, Axum and Katuruka (Kense, 1985).

Furthermore, although Africa is today a net importer of food, the management of crop genetic resources in the past is considered "the single most important aspect of the legacy of indigenous agro-technological knowledge on the continent" (Richards, 1997:16). This level of technological development led to the importation of upland rice from West Africa by Thomas Jefferson in the 1790s for inland planters in the states of South Carolina and Georgia in the US (Richards, 1997). Similarly, Richards (1983) argues that archaeologists must accept the possibility that West African farmers long ago laid the foundation for an "improved" experimental and practical agriculture in the same vein that innovations and experiments by ordinary farmers in England over a period of centuries provided the basis for what eventually became recognised as the "Agricultural Revolution" (Richards as cited in Andah, 1993:254).

However, the absence of modern machine technology and applied science in pre-colonial (or traditional Africa today) remained a great problem for socio-economic transformation and the development of agriculture. As the principal line of production in pre-colonial Africa was agriculture and animal husbandry, the absence of pesticides, chemical fertilisers, disease-resistant seeds, irrigation facilities, veterinary and medical knowledge as well as other technological knowledge and equipment meant that there was an unusual and direct dependence overall on the physical environment in pre-colonial Africa (see Dalton, 1970:66).

Despite these levels of scientific activity, there is very little knowledge about co-operation in scientific and technological activity as well as about the modes of technological transfer or diffusion among the various communities. For instance, Iron and Stone Age societies co-existed, but often very little is known about the mutual impact on each other's way of life and economy. Recounting the emergence of the Old Ghana Empire in the Western Sudan, Basil Davidson (1964:28) notes that this occurred due to the ideas and pressures of the Iron Age coupled with a growing interest in trans-Saharan trade. Quoting an eleventh-century Arabic source, Davidson states that the people of Old Ghana were drawing on much older information and were able to succeed because they fought with iron weapons while their neighbours fought with ebony. This shows that the technological advantage was perhaps not evenly distributed among the various societies in pre-colonial Africa. But as we noted earlier, this may be attributable to the absence of both formal and informal storage of knowledge. Therefore, any overview of the scientific history of Africa before contact with the Arabs and the Europeans and the continent's eventual colonisation has yet to be comprehensively written and will require a great deal more archaeological excavation and dating. A classic example is the discovery of gold artefacts at Mapungubwe in the Northern Province (now Limpopo Province) of South Africa, a region which still lacks a comprehensive history.

Furthermore, in spite of their impressive findings, Schmidt and Avery (1978) argue that more archaeological research is needed to study the way in which the complex iron industry developed along the western shores of Lake Victoria. Meanwhile, in a study sponsored by UNESCO, Posnansky (1981) shows that there is a lack of evidence to substantiate the view that iron technology was transferred from the Nile Valley in Egypt to East Africa. Moreover, an understanding of the pre-colonial phase is made more difficult because of the nature of the scientific interests of the early period of European contact: a study of botany, zoology and geology predominated, while astronomy, geophysics and cluster of geographical sciences such as cartography, hydrology and meteorology were also of great importance. Yet anthropology, archaeology and ethnology, which would have assisted in understanding the scientific history of this phase, were ranked in a secondary position (see, for example, Basalla, 1967:611). However, this aspect of scientific history remains uncharted changed after colonialism.

However, the increasing interest in indigenous knowledge (IK) lends credence to the importance of pre-colonial science to our understanding of the complexities of modern science. Thus, a number of international IK resource centres have been established with various internationally co-ordinated research programmes (Thompson, 1996:105). There are currently eleven such IK resource centres in Africa.[1] Today's application of biotechnology in agricultural and the pharmaceutical industries, which has heightened the relevance of biodiversity in developing countries and for the exploration and the use of plant genetic resources, adds to our understanding of pre-colonial science. It has also brought up the

[1] For example, see the Centre for International Research and Advisory Networks in the Netherlands (http://www.nuffic.nl/ik) for the data on these resource centres.

importance of compensating developing countries and communities after the commercial exploitation of such plant genetic materials.

For example, the Kung people (a subdivision of San people in South Africa) are currently in a potential battle with Pfizer, the giant pharmaceutical company, over the company's possible use of Hoodia cactus to develop a drug as a cure for obesity, without directly compensating them for the use of their indigenous knowledge.[2]

3.2.2 Colonial science and technology[3]

Long before the scramble for and formal partition of Africa by the colonial powers following the Berlin Conference in 1884/5, the services of European scientists were enlisted by private companies and interested individual scientists to help identify the agricultural and other natural resources of the continent, including its fauna and flora. According to McKelvey (1965:318), these researchers worked in terms of deeply rooted traditions of the early investigations on taxonomic and economic botany, and they thus following a course of development parallel to that in Europe and other parts of the world. McKelvey notes that, in the plant sciences, much taxonomic work was done on African material from the late 1700s to the middle 1800s. For instance, in Sierra Leone a company employed Adam Afzelius, a Swedish botanist, to work in the territory from 1792 to 1794; the Royal Botanical Gardens at Kew in Britain published a book on the flora of Africa; the botanical work *Flora Capensis* was initiated in 1839; in 1868 work on the flora of tropical Africa begun to appear; and from about 1839 to 1855 a Dr Schimper worked on the flora of Ethiopia. However, it was during the period between 1880-1950 that the colonial powers gradually assumed increasing responsibility for the development of agriculture and later tropical medicine in sub-Saharan Africa. Before the Berlin Act and the subsequent scramble for Africa, the metropolitan powers tended to follow a policy favouring the expansion of markets rather than development through government intervention (see, for example, Yudelman, 1975:337).

However, as the European powers began to scramble for African raw materials and of course economic, social and territorial control (colonialism), "the work of the early zoologists and botanists who had catalogued the African flora and fauna provided the focal points for the

[2] "Diet Pill: San might sue Pfizer". *Mail & Guardian* 22-28 June 2001:5.
[3] Basalla (1967) first used the term "colonial science" to mean dependent science because scientific activities in the newly colonised territories were based basically upon the traditions and institutions of a nation with an established scientific culture, in this case Western Europe.

development of research institutions" (McKelvey, 1965:318). Besides the work of economic botanists and zoologists, it was primarily explorers and military personnel who conducted scientific research before the establishment of colonial research institutions in Africa with metropolitan public funds. Other researchers included amateurs in mission schools or medical personnel affiliated to religious organisations, local administrators as well as scientific missions sent by metropolitan governments, scientific societies, universities and commercial societies. The technical services of local colonial administrations also conducted some form of research. However, there was less research carried out under the auspices of philanthropic foundations, international organisations and states without territorial control in Africa (Davis, 1982:28).

Thus the nature of colonialism changed dramatically with the introduction of formal S&T into Africa and the concomitant attempts by colonial rulers to manage research and development in the colonies in such a way that the motherland would reap maximum scientific and material benefits. The colonial era also witnessed the introduction of forms of "international" or, perhaps more correctly, trans-border or inter-territorial co-operation in the S&T field (Nel & Teng-Zeng, 1999). First and foremost, all the different colonial governments concerned themselves with the administration of individual territories and policies (*cf.* the French policy of assimilation and the British policy of indirect rule, for example). It was not until the end of the Second World War that there was rapid development towards co-operation among the various colonial powers. This was made possible through the creation of the Commission for Technical Co-operation in Africa South of the Sahara and the Scientific Council for Africa South of the Sahara (these two institutions are discussed later). However, in terms of the number of territories they controlled in Africa, the British and French were the major colonisers. As such, they were in a position to build the first regional S&T institutions.

3.2.3 British Colonial Science and Technology

Interests in agriculture and the mineral sciences as well as in tropical medicine dominated scientific and technological activities in the colonies. The early research in agriculture was conducted through the establishment of botanical gardens to undertake plant research, something which was influenced by the Royal Botanical Garden at Kew in London. At Lagos (Nigeria) a botanical garden was established in 1887; the Royal Niger Company also founded a garden for the distribution of plants at Asaba in 1888 and established four other agricultural stations at various locations between 1889 and 1890 for experiments with coffee, cocoa and other crops. Ghana (then Gold Coast) also had a government botanical garden in 1890 at Aburi (McKelvey, 1965:319). The Colonial Research Committee was established in 1919 to assist colonial governments; the Empire Marketing Board (1926) included some provision for research support, and the Colonial Development Act and Colonial Development and Welfare Act of 1929 and 1940, respectively, made some research funds available (Jeffries, 1964 & 1956; Hailey, 1956; Forje, 1989:20).

A more successful attempt was made in 1929 with the promulgation of the Colonial Development Act which, among other things, sought the promotion of scientific research, industry and experiments in the science, methods and practice of agriculture and industry, the organisation of co-operation, and the growing and marketing of produce (Jeffries, 1964:15).

However, the British government's Colonial Development and Welfare Act of 1940 marked a change in the organisation of scientific activities. This Act was regarded as having a more or less comprehensive programme of development assistance, and it initially allocated about 10 percent of its funds to colonial research and development (R&D). This meant that a colonial research system complete with specialised research councils permitting central co-ordination was built around new or rehabilitated colonial and metropolitan scientific institutions. Moreover, the Colonial Research Committee advised the Secretary of State for the Colonies, who administered the Colonial Development and Welfare fund from 1942. Forman (1940) notes that the formalisation (or institutionalisation) of a regional approach to scientific development in British Africa coincided with the introduction of funding and co-ordinating mechanisms and with the organisation of conferences at the metropolitan level (Forman cited in Eisemon *et al.,* 1985:194). The elements of an "imperial research system began to emerge during the inter-war years, initially having service functions: central information collection and dissemination, scientific function, scientific training at the Imperial colleges, training centres, *ad hoc* advisory committees, missions and periodic conferences" (Eisemon *et al.*, 1985:194).

In 1945 a directive from the Secretary of State required all the territories to prepare a ten-year development plan each and in these plans the emphasis was placed on the improvement of agriculture and animal husbandry as the main economic activities in most of the colonies. To some extent education and health services were also given priority.

Central to the organisation of colonial policies was the formation of advisory and research committees or councils to assist the Colonial Office on the economic aspects of its functions. The first was the constitution in 1929 of the Colonial Advisory Council of Agriculture and Animal Health, whose mandate was extended in 1943 to include forestry. An Advisory Committee on Fisheries was constituted in 1943 and, most importantly, an Advisory Committee on Co-operation in 1947. The Committee on Co-operation played a crucial role in facilitating inter-territorial and later inter-colonial co-operation in subsequent years.

From a modest beginning in 1929 only two long-range inter-colonial centres of research in agriculture were in full operation at the Imperial College of Tropical Agriculture in Trinidad and the East African Research Station at Amani in Tanganyika by 1939 (Jeffries, 1964).[4] According to Sir Charles Jeffries (1964), three main principles guided the development of scientific institutions (facilities) in British colonial Africa:

- the facilities should be in the colonies rather than in Britain;
- research should be organised on a sub-regional rather than on a territorial basis; and
- colonial administrations should share in supporting the costs of research facilities and eventually bear complete responsibility for them (see Eisemon & Davis, 1997:108-109).

Therefore, to accomplish this regional approach to colonial S&T, research councils were created in British Africa which formulated regional research policies and priorities and then made recommendations on the allocation of research funds, as well as on projects assigned to institutes. This also implied that requests for funds emanating from territorial and inter-territorial research institutes and services were vetted first and foremost by regional councils, followed by review committees for various applied sciences that finally reported to the Colonial Research Committee (Eisemon *et al.*, 1985:194).

As we have already noted, during British rule prominence was given to the agricultural sector of the colonies and institutions were created that linked a number of colonial territories, especially after the Second World War. In British East Africa the High Commission provided the avenue for co-operative action by the territorial governments.

[4] Amani in Tanganyika was the only station in territories with a long-term agricultural research programme. The station was initially established by the German Administration in 1902. It came under British jurisdiction after the defeat of Germany in the First World War (see Hailey, 1956).

In 1947, therefore, decisions were taken to establish the East African Agricultural and Forestry Research Organisation (EAAFRO), which became a reality in 1950 with the completion of laboratories, offices and accommodation at Muguga near Nairobi;[5] the East African Freshwater Fisheries Research Organisation (EAFRO) at Jinja in Uganda; Tsetse Fly and Trypanomiasis Research and Reclamation Organisation in Nairobi and Marine Research Station at Zanzibar were also established (Jeffries, 1964:28-29). Other inter-territorial organisations, including medical institutions, were created for the Anglophone countries of Kenya, Tanzania and Uganda. In fact, from modest beginnings in 1929 with the establishment of the East African Meteorological Department in Nairobi, about 15 inter-territorial scientific and technical services has been established in British East Africa by the mid-1950s (Eisemon *et al.*, 1985:194). These broadly fell under the East African Common Services Organisation (EACSO) as the overall co-ordination body (Forje, 1989:194).

In British West Africa five major inter-territorial research organisations were created between 1950 and 1954. Among these were the West African Cocoa Research Institute (WACRI) and the West African Oil-Palm Research Institute (WAIFOR), which was established in 1951 to improve oil palm production. (Jeffries, 1964:29) notes that these two organisations were already well established and financed by the local governments without the assistance from Colonial development and Welfare funds.) The others were the West Africa Maize Research Unit (WAMRU) to help plant breeders develop corn rust-resistant maize varieties that had entered Sierra Leone in 1949 as a staple food, and the West African Rice Research Institute (WARRI) at Rokupr in Sierra Leone for Anglophone West Africa. Also in operation was the West African Institute for Trypanosomiasis. The overall research activities in the Gambia, Ghana, Nigeria and Sierra Leone were co-ordinated by the West African Research Organisation (WARO).

In the southern African region the three territories (including now Malawi, Zambia, and Zimbabwe) which constituted the Federation of Rhodesia and Nyasaland (1953) carried out agricultural research under the aegis of the Federal Agricultural Research Council (Forje, 1989:20). However, British Central Africa, as it was known, did not have well-developed inter-territorial scientific institutions or services.

Besides the natural sciences, in the social sciences some regional institutions were created; they included the East African Institute of Social Research based at Makerere, which began

[5] Amani later became a sub-station of EAAFRO from 1950.

to function in 1950, the Rhodes-Livingstone Institute in Northern Rhodesia, the West African Institute for Social and Economic Research and the West African Road Research Laboratory. Crucial to these arrangements was the facilitation of the mobility of scientists from the various territories to meet and share ideas, which led to the emergence of S&T activities in the various sub-regions.

3.2.3.1 Funding of British colonial science

The establishment of the Department of Scientific and Industrial Research in 1916 with its own Parliamentary vote for funds was the first attempt at institutionalising research in United Kingdom which was to have a positive impact on colonial science. In 1919, therefore, the Colonial Research Committee was created with a Parliamentary grant of £100,000 to be spread over a number of years. This grant was to assist only the "less prosperous" territories and the Committee mandate covered research in mineral resources, agriculture, animal health, forestry and fisheries with the exception of medical questions (Jeffries, 1964:14). The Empire Marketing Board was also established in 1926 with an annual budgetary allocation of £1 million for the purposes of financing schemes for the promotion of the sale of products from the Empire in the United Kingdom.

In 1929 the Colonial Development Act first broke new ground by creating a Colonial Development Fund of £1,000,000 a year "to aid and develop agriculture and industry in the Colonies, thereby promoting commerce with and industry in the United Kingdom" (Jeffries, 1956:150). In all, a total sum of £397,654 was recommended for assistance in the category of research, co-operation and marketing during the period of the Act from 1929 to 1940, and this provides a fair indication of the funds made available for the promotion of research. This represented about 7% of the total of £8,875,083 recommended under the Act (Jeffries, 1964:15-16).

However, the enactment of the first Colonial Development and Welfare Act of 1940 was an improvement and also meant that more funds were made available for the development of all the British Colonies. In its first allocations the Act provided for a maximum expenditure of £5,000,000 a year for ten years on schemes of economic and social development, as well as £500,000 a year for research. Later the currency of the Act was extended and the total funds increased, first to £120,000,000 and later to £140,000,000 for a ten-year period that was due to end on 31 March 1956. A new Act was passed in early 1955 which provided for a further

£80,000,000 which, with the unspent balance of £40,000,000 still remaining under the previous Act, made a total of £120,000,000 available up to 1960 (Jeffries, 1956:151).

According to Jeffries (1964:30-31), out of the allocation of over £7.5 million made from Colonial Development and Welfare funds in the period 1940-1950, nearly one third was spent on agriculture, veterinary and forestry schemes, about 14% on medical research and almost 9% on social and economic research. In geographical terms about 37.5% of the total allocation was for schemes set to benefit the East African territories, 19% for the West African colonies, 13% for the West Indian Colonies, British Guiana (Guyana) and British Honduras. However only £2,845,325 was actually spent or disbursed by the British government.

The significance of this development to this study is that, since the inception in 1940 of the scheme, the central council noted in 1953 that £11.1 million was promised for research in Africa. Out of this amount £5.5 million was actually disbursed, of which 39% went to East Africa, 18.3% to West Africa and 6.2% to Central Africa. While some expenditure was territory specific, others were inter-territorial by nature. For instance, in 1953 £40,000 went to air-spraying in East Africa and £70,000 to three tsetse pilot projects with £130,000 from the Colonial Development and Welfare Fund. However, the three territorial governments of East Africa were to contribute about £340,000 to the project. West Africa got £34,500 for research on a new plant disease, maize rust (*African Affairs*, 1953:59 from the report on *Colonial Research,* 1951-2), which prompted the formation of WAIMR.

Overall, the adoption of a regional approach to the administration of science after World War II greatly enhanced East Africa's scientific development as compared to the other two regions. According to Davis (1982), between 1940 and 1960 East Africa claimed about 39% of the Colonial Development and Welfare research funds. This share is disproportionate to the size and relative research capacity of the East African Scientific Community. Even though West Africa was in some respects more scientifically developed and possessed a larger scientific community, it received a much smaller proportion of these funds (see Eisemon *et al.*, 1985:194).

The formation of the East African Community and the East African University in 1963 helped promote regional co-operation in science. This firm foundation later survived the dissolution of the East African University in 1970 to extent that the East African Academy produced a Regional Science Plan in 1974 for the Community for consideration (Eisemon *et al.*, 1985).

An organic component of this inter-territorial co-operation was the creation of mechanisms to review the progress made in the previous year. For instance, the West African Council with its secretariat at Accra was set up in 1945 to secure the co-ordination of the four territories. It was later superseded in 1951 by the West African International Conference, which met annually to review the progress made in co-operation in research as well as in social and economic policy. The East African High Commission co-ordinated scientific and social research. In Central Africa the co-ordination of research was one of the functions of the Central African Council, which was created in 1945. However, this Council was not as effective as the ones in East and West Africa (Hailey, 1956:1607-8).

The rising national assertiveness during the 1960s following the independence of most territories led to the collapse of this effort at regional approaches to the development of S&T capabilities. Eisemon *et al.* (1985:196) put it as follows: "... regionalism in science and education ran counter to the tendency throughout Africa to transform scientific and educational institutions into instruments of the state". This led to what we shall discuss later as the national phase of the evolution of scientific and technological development in Africa.

3.2.4 French Colonial Science and Technology

Science and technology developed slowly in the French colonial territories in Africa. In fact, initially almost all the scientific institutions were based in Paris in France. These included the *Musée National d'Histoire Naturelle*, which had a section devoted to tropical agriculture and the *Ecole Supérieur d'Application d'Agriculture Tropicale*, which provided the training for Colonial Agricultural Officers. It was the Pasteur Institute which pioneered the organisation of research activities in the region with the establishment of its local branches (Hailey, 1956:918). Gaillard *et al.* (1997:28) confirm this, noting that the major translocation of French science in Francophone Africa from the late nineteenth century until the 1950s was the "institutional radiation" of, for example, the establishment of six local Pasteur institutes in Saigon (1890), Algiers (1894), Nhatrang (1895), Madagascar (1902), Tunis (1903), Brazzaville (1910) and Dakar (1913) (also see Forje, 1989:21; Eisemon *et al.,* 1985:193). According to Eisemon *et al.* (1985:193), these institutions performed some experimental research, produced vaccines and provided routine diagnostic services. Thus far the work which was sponsored by the Pasteur Institute in North Africa has produced the only two Noble Prizes in medicine for Africa, one to Laveran in 1907 for his work on malaria and the other to Nicolle in 1928 for his work on typhus. It was not until 1938 that the French established the *Institut Français d'Afrique Noir* (IFAN) to conduct research into all African problems, including those in the social sciences (Hailey, 1956:1608; Forje, 1989:21). Meanwhile, at this point these research activities were never co-ordinated at either the inter-territorial or metropolitan level.

The creation of the *Office de Recherche Scientique Coloniale* in October 1943 marked the first attempt at research co-ordination in the French colonies. Thereafter French colonial authorities operated mainly through the *Office de la Recherche Scientifique Technique Outre-Mer* (ORSTOM – Office for Overseas Scientific and Technical Research),[6] which had research organisations for Francophone Africa. These included the Institute for Research in Tropical Agriculture (IRAT), the Institute for Research on Oil and Oil-bearing Plants (IRHO), and the Institute for Research on Cotton and Textiles (IRCT). Generally, ORSTOM was responsible for basic research carried out in the various areas of coffee, cocoa, tea, tropical forests, rubber, rice, etc. (Forje, 1989:195; see also Gaillard & Waast, 1992:43). Most of these institutions had been established to extract and promote exports crops as raw materials for industrial production in Europe to the detriment of basic food crops.

Unlike the British case, "only modest effort was accorded by French colonial or metropolitan authorities to the development of research activities in African colonies" (Eisemon *et al.,* 1985 as cited in Forje, 1989:21). It can also be argued that there were fewer institutional linkages and less co-operation among Francophone colonies in the field of science and technology. According to Forje (1989:21), there was no co-ordination of French colonial policy on scientific and technological activities. Hence, the S&T activities of each institute or territory was explicitly and implicitly assimilated and undertaken by research institutions in metropolitan France which had African branches. Moreover, the regional centres so established were controlled by the French in terms of central management and staffing, as these centres were dominated by expatriates and no concrete efforts were made to develop the local capacity for independent research in the colonies.

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[6] The *Office de la Recherche Scientifique Coloniale* later became *Office de la Recherche Scientifique Outre-Mer* (ORSOM) and its name finally changed to ORSTOM in 1953.

Some of these established regional centres in Africa, for example, were located at Bambey for the Sahelo-Soudanian zone, Bouaké and Bingerville for the wet tropics, Boukoko for the equatorial zone, Loudima for the Guinean zone, and at Lake Alaotra for the medium altitude (Gaillard & Waast, 1992:42). Their actions were frequently justified by the policy of assimilation, since African colonies were considered as extended provinces of the motherland, France. Furthermore, due to the extractive nature of French commercial activities or interests in Africa, they did not require much research and governments did not develop an active interest in science-based colonial agriculture until much later (Eisemon *et al.*, 1985:193; see also Forje, 1989:21).

3.2.5 Other Colonial Powers

Besides the British and the French, other colonial powers in Africa included the Portuguese, the Belgians and the Spanish.[7] These countries had their own scientific research institutions within or outside Africa. The Belgium State Botanical Garden in Brussels had a large collection of tropical plants and had a Botanical Department at the *Musée du Congo Belge.* The University of Louvain was much involved in research in the Congo and had a Centre devoted to this. However, the creation in 1933 of the *Institute National pour l'Étude Agronomique du Congo Belge* (INEAC – the Belgian Congo Institute for Agronomic Studies) for both agricultural and veterinary research was a major turning point in Belgian colonial science. By June 1960 the INEAC had 32 experimental centres, stations and plantations located in eight geographical regions throughout Congo and Ruanda-Urundi, besides the Yangambi research centre (Gaillard & Waast, 1992:43). At these centres research was carried out on plants such as rubber, oil palm and coffee, cotton and cocoa. In veterinary science research was conducted on the control of pests and the improvement of indigenous cattle. The Portuguese territories of Angola, Guinea and Mozambique were the main colonies controlled by Portugal. In Mozambique animal husbandry dominated colonial research into cattle farming, supported by a laboratory for veterinary pathology. Similarly, Angola had a veterinary laboratory in the highlands and stock farming areas at a number of districts including Cuanhama, Ganda, Humpata and Quilengue (Hailey, 1956:919-920).

[7] In view of the fact that South Africa and Southern Rhodesia were more like settler colonies, these two have not been considered as colonial powers. Moreover, these two powers developed the infrastructure and resources for the development of their respective areas, although some resources were taken away.

The above colonial scientific activities were either conducted within each colonial territory or among a number of territories under a particular colonial power. In sub-regional terms scientific activities in sub-Saharan Africa were undertaken in eight regions: three British (East Africa, West Africa and Central Africa), two French (West Africa and Equatorial Africa), one Belgian (Congo), one Portuguese (however, Mozambique and Angola could be considered as two separate regions), as well as the Union of South Africa with its own scientific environment (see Worthington, 1958; Davis, 1982). However, the problems and demands of scientific research were such that the individual colonial powers could not continue to work alone, not even for the benefit of the African colonies. Hence the need for inter-colonial scientific co-operation became more evident, particularly after the Second World War.

3.2.6 Inter-territorial Co-operation in Colonial Science and Technology

3.2.6.1 Early background

International co-operation tends to provide benefits to individual members on matters they cannot deal with on their own. Such benefits include the reduction of transaction costs and the provision of information to governments (Keohane, 1998; Keohane & Nye, 1985).[8] Early efforts at co-operation in the scientific field in Africa were initiated at the Brussels Conference of 12-15 September 1876, where geographical societies and African explorers in Europe and the United States were in attendance.[9] The Conference discussed the question of the exploration and the so-called civilisation of Africa, and the opening up of the interior of the Continent to "commerce, industry, and scientific enterprise of the civilised world" (Keltie, 1895:120). However, most of the delegates were there in their individual capacities and not as representatives from their governments. King Leopold of Belgium, who attended the

[8] Davis (1982:94-95) argues that the need for inter-colonial scientific co-operation was based on three factors: firstly, the recognition of common problems confronting the same territories which require common attention; secondly, the desire of the metropolitan powers to keep South African influence under check in the region, since South Africa frequently expressed her ambition of expansion northwards both economically and politically; and thirdly, the uncomfortable scrutiny to which colonial powers were subjected in the United Nations and the common desire among colonial powers in Africa to develop ways to attenuate criticisms and possible supervision by the United Nations.

[9] Before this conference early societies with colonial interests were formed in all the metropolitan countries, with a specific focus on Africa. These included humanitarian and geographical societies such as the British Association for Promoting the Discovery of the Interior Parts of Africa (1788), Société de Géographie de Paris (1821), Gesellschaft für Erdkunde zu Berlin (1828), The Ethnological Society of London, the Société d'Anthropologie de Paris (1859) and the Anthropologische Gesellschaft (Vienna, 1870), all of which sponsored travellers and promoted commercial interests at various levels as well as the spread of Christianity and the

Conference, was there in his personal capacity and his presence was not in any way related to his Kingdom's responsibility. At this Conference it was agreed that an International Commission or International African Association for "scientific and benevolent purposes" should be established, with its seat at Brussels. The purpose of this Commission or Association was the exploration and civilisation of Central Africa; each nation willing to co-operate was to form a National Committee to devise common objectives and send their delegates to the Commission. National Committee branches of the Association were formed in countries such as Austria, France, Germany, Hungary, Italy, the Netherlands, Portugal, Russia, Spain, Switzerland and the United Sates as well as in Belgium. But Britain refused to send any delegate to the Commission in Brussels and instead the British Royal Geographical Society set up its own African Exploration Fund in 1877 (Keltie, 1895:121-122).

Furthermore, other colonial powers felt that the various national research institutes could perform what the Commission intended to do and hence the international channel of the movement was not maintained, although in 1877 it sent out its first expedition to the East Coast and Lake Tanganyika. This expedition was a failure, but its efforts led to the establishment of the Karema Station on the south-east shore of Lake Tanganyika in 1880. Experiments were conducted, at King Leopold's expense, with Indian elephants brought to Africa. The elephants died and later the Karema Station fell under the German protectorate (Keltie, 1895:123-124). The early failure of the Association led subsequently to the formation of the *Comité d'Études du Haut Congo* (Committee for the Investigation of the Upper Congo) in 1879, which later became known as the International Congo Association. At this stage of colonial history there was still intense competition among the various European powers in securing territorial control in Africa and, in order to lessen or prevent bitter rivalry among them, the Berlin Conference was organised from 15 November 1884 to 30 January 1885. The General Act of the Berlin Conference therefore laid down the important rules, which were to guide the colonial powers in their great scramble for and partition of Africa. The Act required each power to notify the others about any territory it occupied. For scientific purposes the International Congo Association attended the Conference as an independent body and sought to have the Congo River Basin and its surrounding areas declared the Congo Free State (now the Democratic Republic of the Congo). However, it later became the property of King Leopold and later a Belgian colony. After the Berlin Conference every territory acquired was

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production of information (see Davis, 1982:33). Also, the missions funded by these societies usually combined commercial, exploratory and scientific research.

then ruled as a colony or protectorate and scientific research continued to be conducted under the jurisdiction of the individual colonial powers, particularly from the last decade of the nineteenth century. As Henry (1953:309) notes: "The French wanted to go faster than the British and the British to do better than the Belgians or the Germans. In so doing, the administrators, officers and technicians had only one objective, which was to establish their own control of the territory; international co-operation came only second or third, when it was possible at all". Hence the benefits of inter-colonial co-operation were delayed.

3.2.6.2 After the partition of Africa: 1886 and beyond

As we noted earlier in our discussion, there were successes in individual colonial territorial scientific endeavours. Nonetheless, despite the success of these institutions under the different colonial powers, these powers still realised that to exploit the resources in Africa effectively they needed to co-operate among themselves on a continental or pan-regional basis. Hence the foundation for intergovernmental co-operation in science and technology in Africa was laid by the four colonial powers which were ruling in Africa in 1950, that is, Belgium, France, Portugal and the United Kingdom, including the two governments of the Federation of Rhodesia and Nyasaland and the Union of South Africa. This co-operation led to the formation of the Commission for Technical Co-operation in Africa South of the Sahara (CCTA) and the Science Council for Africa South of the Sahara (CSA). The CCTA had its headquarters in London and the CSA in Zaire.

Prior to the establishment of these two institutions in 1907 the French, British, Belgians and Germans met at Brussels and discussed the possibility of an international technical co-operation on sleeping sickness. However, this first attempt of technical co-operation was not possible because of what Henry (1953:309) calls "the obstinacy of French diplomacy" and the fact that France wanted to retain central organisation in French territory. The British and the Germans later created a bureau to study sleeping sickness, but the outbreak of the First World War brought that to an end. We might also mention that after the First World War, during a period which saw the formation of the League of Nations and the forfeiture of German colonies in Africa, there was a reorganisation of colonial territories with the British and French sharing as well as assuming trusteeship of the former German colonies.

After the War the organisation established by the League of Nations for dealing with health questions carried out important investigations into public health problems which were shared by a number of African colonies. There were also a number of joint consultations on agricultural or pastoral problems. According to Hailey (1957:1609), "the development of definite agencies for inter-colonial co-operation in research may be said to be the fruits of the Second World War", just as the First World War brought about co-operation among the British, Belgians, French and Portuguese on military terms. The initial problem was that, at the outbreak of the War in 1939, Africa was divided into two: a neutral Africa and allied Africa. But co-operation between the territories in Africa on the military side started in 1942 and 1943, when more than half of the French territories joined the allied group (Henry, 1953).

In November 1945[10] formal discussions were held between the representatives of the Ministry for Overseas France and the British Colonial Office with the hope of achieving some form of general co-ordination of policy in colonial affairs (particularly an Anglo-French agreement on technical co-operation). As the discussion proceeded it became clear that the first and most promising field for co-operation lay in the joint study of technical rather than political problems. Examples were the International Convention on Air Navigation in 1933 and a joint scheme for the control of locust swarms put forward by the French government and accepted by the British government in 1938, but the scheme had hardly been implemented when the Second World War started. Yet the greater need for regional co-operation in this particular field led to the formation of the *Office National Anti-Acridien* in 1943. It covered French North and West Africa, and the East African Locust Directorate for North Eastern Africa, which during the war years organised co-operative measures through out the Middle East. Added to these was the success of the first Inter-African Forestry Conference held at Abidjan in 1943 that served as a source of encouragement for co-operation (Hailey, 1957:1609).

The establishment of formal institutions for co-operation in research was preceded by years of discussion between the French, British and Belgian governments. A number of bilateral agreements for technical co-operation were concluded between the French and the Belgians,

[10] Before 1945, at the Rhodes Memorial Lecture delivered at Oxford in 1929, General Smuts raised the point that the African territories were being developed under the control of a number of different European powers. According to Smuts, however, there was great variety and inconsistency in the policies and practices of the administering authorities, and there was an urgent need for a survey of what was taking place in Africa as a whole (Jeffries, 1964:19). Smuts's statement is often considered as stimulating co-ordinated research and co-operation among the colonial powers.

the Belgians and the British, the Portuguese and the British, the French and the Portuguese, as well as the British and the French. A series of specialist conferences were held and, although the participation varied on different occasions, the British and French territories were represented in all. For instance, a veterinary conference was held at Dakar in 1946 which resulted in the establishment of a closer liaison between the British and French Veterinary departments.[11] In the same year a medical conference was held at Accra and the French and British governments extended invitations to Liberia, Belgium and Portugal. This conference became a regional success. Following this success, a conference was organised at Dakar in 1947 where a list of projects was drawn up to improve communication between the French and the British territories. In the same year the French, Belgian and British experts also discussed mass education in London and nutrition in Paris.

Furthermore, a forestry conference was held at Brussels, where experts from the United Kingdom, France, Belgium, South Africa and Portugal discussed methods of control of plant diseases and the adoption of a uniform system of nomenclature for forest products. A conference on trypanosomiasis was held at Brazzaville in 1948 and was attended by representatives from almost all the territories of Africa south of the Sahara. It led to the establishment in the Belgian Congo of the permanent bureau of the World Health Organisation dealing with the problems of tsetse fly and trypanosomiasis. An inter-African conference on rinderpest was held in the same year at Nairobi. An international committee for locust control – representing French and British territories in West Africa – was also set up in 1948 with the object of preparing an international convention on the subject (Hailey, 1957:1610).

3.2.6.3 Institutionalisation of co-operation

In spite of the above interregional activities, however, there were no permanent institutions to organise and co-ordinate these regional conferences except on an *ad hoc* basis. Therefore there was need to create a permanent advisory body on scientific research which could cover all of Africa south of the Sahara. Thus the genesis of co-operation was initiated following a recommendation made at the Commonwealth Scientific Conference[12] held in London in 1946, which called for a pan-African science conference to discuss the possibilities for collaboration in scientific research among the various territories in Africa South of the

[11] This was the first Franco-British Conference fostering inter-African co-operation on a regional basis.
[12] The first British Commonwealth Scientific Conference was held in 1938 in London.

Sahara.[13] Then in 1948 the six of the colonial governments responsible for the welfare and the social, scientific and technical progress of Africa South of the Sahara agreed to launch, within the regional framework and in direct relation to the needs of the African continent and populations, a long-term programme of scientific and technical conferences and exchange of technicians and research workers (CCTA, 1956:1).

Subsequently the First African Regional Scientific Conference (ARSC) was held in the Union of South Africa from 17 to 28 October 1949 at the University of the Witwatersrand in Johannesburg.[14] The conference was organised by the South African Council for Scientific and Industrial Research (CSIR) with the support of the Union Government (*South African Journal of Science - SAJS,* 1949:137; Worthington, 1958:49). In his opening speech then Prime Minister of the Union, D F Malan, noted that the object of the Conference was not "to consider in detail the problems confronting the specialists in agriculture or veterinary science, or geology, chemistry, medicine or the social science but the broader and greater problem of how to bring about a co-operative application of scientific research to the problems of the African continent". For Malan the success of laying the foundation stone of such an edifice will be regarded by posterity as "one of the major achievements of our time" (see First African Regional Scientific Conference, 1949).

This historic Conference was attended by more than 100 representatives; the governments of all the territories in Africa south of the Sahara were represented, with the exception of Liberia and the Spanish colonies. The following people served as the leaders of their main delegations:

- Professor J Millot, then Director of the Institute of Scientific Research in Madagascar, leader of the French delegation;
- Sir Ben Lockspeiser, leader the United Kingdom delegation;
- Dr S A A E M Correia, leader of the Portuguese delegation; and
- Dr P Staner, leader of the Belgian delegation.

[13] There is a common view that the actual move towards scientific co-operation was made by General Smuts in his address at the Rhodes Memorial Lecture at Oxford in 1929. Smuts is said to have drawn attention to the diverse and uncoordinated activities of European powers controlling Africa and made a plea for a survey of the whole situation to find a way to facilitate the exchange of information and experience in and about Africa (see Hailey, 1936; Worthington 1958; Jeffries 1964; Gruhn 1967).

[14] Apart from the six colonial powers, representatives from UNESCO, WHO, FAO and the United States attended the conference as observers.

Dr P J du Toit, then Deputy President of the South African Council for Scientific and Industrial Research, chaired the Conference. Its deliberations covered six broad sections and the themes included Physical Environment; Soil and Plants; Zoology and Animal Industry; Health and Medical Research; Social Research and Technology. In line with the deliberations at the Conference, a number of recommendations were made, among which were the establishment of a Commission for Technical Co-operation and a permanent advisory organisation, that is, a Scientific Council for Africa South of the Sahara.

3.2.6.4 The Commission for Technical Co-operation and the Scientific Council for Africa

Following the recommendations at the end of the Conference in 1949, the six governments of Belgium, France, Great Britain, Portugal, Southern Rhodesia and the Union of South Africa established the Commission for Technical Co-operation in Africa South of the Sahara (CCTA) and the Science Council for Africa South of the Sahara (CSA) in January and November 1950 respectively. The main objective of the Commission (CCTA) was to ensure technical co-operation between territories for which member governments were responsible in Africa south of the Sahara. The powers and functions of CCTA were:

- To concern itself with all matters affecting technical co-operation between the member governments and their territories within the territorial scope of the CCTA;
- To recommend to member governments measures for achieving such co-operation;
- To convene technical conferences as agreed by member governments;
- To supervise, from the financial and general points of view, the work of the organisations placed under its aegis and make recommendations thereon to the member governments;
- To make recommendations to the member governments for the setting up of new organisations or the revision of existing arrangements for securing technical co-operation within the territorial scope of CCTA;
- To make recommendations to the member governments with a view to the formulation of joint requests for technical assistance from international organisations;
- To advise member governments on any other subject in the field of technical co-operation which the member governments may bring to its notice;

- To administer the Inter-African Research Fund and the Inter-African Foundation for the Exchange of Scientists and Technicians.

In contrast, the role of the Scientific Council for Africa South of the Sahara (Council) was to be essentially advisory and consultative and it was composed of scientists representative of both their subject areas and the regions concerned. The 1949 Conference also recommended that the Council should also be presided over by a scientist with a knowledge of African problems. The functions of the Council would be exercised in full co-operation with existing inter-territorial organisations and with new bodies or specialists bureaux that might be set up. The Council's major functions were:

- To encourage and establish contacts between research workers in the same or related scientific fields or in the same geographical regions;
- To study what research projects of common interest could be usefully suggested to governments, research agencies or universities;
- To promote liaison between inter-governmental scientific bodies (bureaux) or Regional Scientific Councils;
- To facilitate the exchange and movement of scientific workers between the different territories and countries concerned and, if so requested, to advise on their training;
- To organise the compilation and distribution of reports and information of general value concerning scientific workers, scientific equipment and specialist libraries and facilitate the use of such equipment and libraries in so far as this function is not undertaken by the inter-governmental bureaux or councils;
- To foster in respect of each of the major scientific subjects the creation in Africa of centres of specialised documentation, which should be as complete as possible;
- To convene, with the consent of the governments concerned, periodic conferences of a general scientific character and to facilitate meetings of groups of specialists. These conferences and meetings would review progress achieved in scientific research and would formulate proposals for further scientific development and this would ensure that such conferences are arranged along rational lines;
- To submit recommendations to metropolitan governments concerned, which would be able to secure joint administrative action through the proposed Inter-Governmental

Committee for Technical collaboration or, where this is in order, territorial governments, or to research agencies in Africa (African Regional Scientific Conference Report, 1951:101-102; Cooke, 1949:144).

Both the Commission and the Council came into existence in 1950. Although established in 1950, it was not until 18 January 1954 that the final inter-government agreement was signed in London, thus establishing the Commission for Technical Co-operation in Africa South of the Sahara.[15] Article 1 of the agreement stated that the Commission shall be assisted by the Scientific Council for Africa South of the Sahara, while the Inter-African Bureau of Epizootic Diseases, the Tsetse Fly and Trypanosomiasis Permanent Inter-African Bureau, the Inter-African Bureau for Soils and Rural Economy, the Inter-African Labour Institute, the Inter-African Pedological Service and other such organisations for co-operation within the region were to be recognised by the Commission. Article 6 of the Agreement also reiterated the powers and functions of the Commission, as we have stated above. The CCTA was also to help them discuss common technical problems and to control the technical activities of the United Nations in Africa (Eisemon *et al.*, 1985:195).

The Council (CSA) consisted of fourteen to twenty members, eminent scientific people drawn from the member government and who were mostly working in Africa. Its membership was to be apolitical. They were appointed not as representatives of their governments, but of scientific disciplines or groups of subjects, yet with due regard to the countries to which they happened to belong. In 1958 it was composed of two members (including the chairman) who were South African, three (including the vice-chairman) were French, two were Portuguese, two Belgian, three British and one was a Rhodesian. Together they represented nearly all the major fields of the sciences and as members of the CSA their primary allegiance was to the advancement of science for the benefit of the region as whole (Worthington, 1958:51).

[15] The Federation of Rhodesia and Nyasaland replaced Southern Rhodesia as the Commission's Member in 1954. Meanwhile, Davis (1982) prefers to argue in terms of international law that between 1950 and 1954 the two institutions represented an intergovernmental arrangement rather than being intergovernmental institutions.

The Council held its annual meetings at different centres. Its first session and inaugural meeting was held in Nairobi, Kenya in November 1950 under the chairmanship of Dr P J du Toit, Deputy President of the South African Council for Scientific and Industrial Research. The Council considered all the fifty-three resolutions passed at the African Regional Scientific Conference on scientific co-operation (SAJS, 1951:180). At this historic meeting the Council looked at a number of proposals and decided that the following areas should be examined in detail as its first priority:

- The establishment of an inter-African Regional Bureau on Geology;
- The achievement of cartographic uniformity in the maps of Africa, and the preparation of special regional maps dealing with such subjects as geology, climatology, vegetation, vector-borne diseases, etc.;
- The extension of co-ordinated development in the field of hydrology and water conservation;
- The calling of a specialist meeting on housing and building research;
- The co-ordination of a scientific library and bibliography (SAJS, 1951:180)

The annual meetings were held at different places including Dakar, Bukavu, Tananarive, Pretoria, Luanda and Yangambi. The CSA was the main scientific adviser to CCTA as well as the co-ordinating body between different disciplines.

The CCTA had a different kind of membership because it dealt, on behalf of the six member governments, with executive questions. It was composed of official representatives of these governments. A delegation from each government generally included a liaison officer officially appointed for CCTA and CSA affairs. Operationally, each of the delegations could include scientists and technicians; the official representatives were normally administrators. At each of its annual sessions and intermediate meetings when necessary the CCTA could make recommendations to all six member governments simultaneously and these automatically became decisions of those governments, unless official objections were raised within a period of two months following the meeting. The principle of unanimity was maintained both by the CCTA and by the CSA when recommending action to member governments.

From 1951 to 1954 the CSA and CCTA each had its independent secretariat, the CSA in Africa at Bukavu, and the CCTA in Europe at London. During this period the functional relations between the two institutions and also between each and the dependent specialist organisations were worked out in day-to-day practice. Following these experiences all secretariat functions were amalgamated under a common secretary general on 1 January 1955. This was said to ensure maximum co-ordination between the two organisations. The main CCTA/SCA office was administered by a Secretary General and based in London and a smaller unit administered by an Assistant Secretary General, who was also the Scientific Secretary based in Bukavu in the Belgian Congo (CCTA, 1956; Worthington, 1958:51-52).

3.2.6.5 *Bureaux and services*

Through the organisation of conferences, various bureaux and committees were created even before the CCTA and the SCA were formally established, but these bureaux and committees nonetheless occurred within the period in which pan-African co-operation in S&T was being seriously considered. Moreover, the early bureaux established still fell under the mandate of or became responsible to the CCTA after it came into existence; this happened immediately or at a later stage (e.g. the International Scientific Committee for Trypanosomiasis Research (1948) became responsible to the CCTA in 1955). The first technical conference that was arranged by the six member governments was on the tsetse fly and trypanosomiasis. One of the recommendations of the conference was the establishment of a Bureau Permanent Inter-Africain pour la Tsetse et la Trypanosomiase (BPITT). It was created and located at Leopoldville under joint French and Belgian direction and was housed in the Princess Astrid medical laboratories. In 1949 another conference, on the inter-African rinderpest problem, was held in Nairobi and its recommendation led to the establishment of an Inter-African Bureau for Epizootic Disease (IBED) at Muguga, Kenya (fifteen miles from Nairobi). This Bureau was situated at the central headquarters of the British East Africa research organisations and had a British person as its director. Following the first inter-African conference on soil science held at Goma in the Belgian Congo in 1948, a Bureau Inter-Africain des Sols (BIS) was created. This bureau was based in Paris and was therefore under French direction.

In view of the remoteness of the BIS bureau from the field, an additional body, the Service Pédologique Inter-Africain (SPI) was formed with its headquarters at the INEAC at

Yangambi (Kisangani) in the Belgian Congo.[16] This bureau helped to co-ordinate the work of soil mapping in Africa and assisted in the adoption of uniform methods of soil analysis. Owing to the great variety of work involved in the study of soils and soil conservation, and the fact that Africa is large, four regional soil committees were created at different times, which also held their various annual meetings separately.

These Committees were the Southern African Regional Committee for Soil Conservation and Utilisation (SARCCUS) (formed in 1950), the West African Regional Committee for Soil Conservation and Utilisation (CROACUS) for Western Africa, the Central African Regional Committee for Soils Conservation and Utilisation (CRACCUS) and lastly, the East African Regional Committee for soils Conservation and Utilisation (CREACUS), CREACUS only met for the first time in 1955. The last bureau created at the end of 1955 was the Inter-African Labour Institute (ILI) in Bamako in Sudan Français under a British director (CCTA, 1956:8-10; Worthington, 1955:52-53).

Furthermore, the CCTA made arrangements for controlling plant pests and diseases through the establishment of Inter-African Phytosanitary Commission (IPC), which was administered by its own Commission. Due to the importance of such a body, a permanent information centre was set up that consisted of a scientific secretariat at Cameroon, while the CCTA provided additional secretarial and administrative services. The Commonwealth Institute of Entomology and Mycology also assisted the IPC. Other areas that were covered in the short period of the CCTA were geology, for which an Inter-African Scientific Correspondent was appointed in 1954. He was based in Pretoria and his functions were to maintain contact with other geological departments and work in close consultation with the pre-existing Association of African Surveys. The National Building Research Institute of the South African Council for Scientific and Industrial Research (CSIR) provided the permanent secretariat for an inter-African committee on building and housing. While in Lisbon the Portuguese government provided the secretariat for the inter-African committee for statistical studies, which used to meet once a year (Worthington, 1958:55).

[16] After independence in 1960 the Mobutu regime changed this name to Zaire; however, after the overthrow of Mobutu, who eventually died in exile in France, the military regime again changed the name from Zaire to the Democratic Republic of the Congo in 1998 (DRC).

3.2.6.6 Reorientation of CCTA/CSA and the Fondation d'Assistance Mutuelle en Afrique (FAMA)

By 1956 the establishment of functional scientific and technical co-operation in Africa was judged to be "a race against time" because of the imminent political changes on the continent as a result of demands for political independence. The gaining of independence by Ghana (the Gold Coast) in 1957 meant that eventually all independent African countries would have to be admitted as members of the CCTA/SCA.

But this problem was anticipated and in 1957-8 two changes occurred: the admission of Ghana and Liberia also meant that steps had to be taken to make the CCTA/SCA competitive in technical assistance through the Fondation d'Assistance Mutuelle en Afrique (FAMA). Both of these changes were considered as realistic adaptations of the CCTA/SCA to the new Africa. This strategy of the CCTA/SCA was to encourage the participation of African states and to find ways and means of making the Commission a useful part of the African regional environment (Davis, 1982:109-110).

FAMA was designed to co-ordinate technical assistance resources among CCTA member states with few multilateral commitments (assistance was to be arranged bilaterally) to serve as an intermediary between these states and the global agencies and to receive the semi-independent African states into the international sphere. Besides, FAMA was to serve as the agency through which non-member governments in Africa and international agencies could receive and offer technical assistance (Davis, 1982:113). In terms of technical assistance FAMA was to provide expertise, specialised training and, lastly, scientific and technical materials, of which the provision of specialised training was the main FAMA activity. And with regard to specialised training, the FAMA offer of assistance exceeded demands or requests from the African governments. Thus about 50 experts per year were provided to African governments and about 350 scholarships were allocated by FAMA to African scholars from 1959-1961, while it organised a number of conferences for the training of middle-grade manpower (Davis, 1982:115).

These patterns of inter-governmental co-operation through the CCTA and SCA also led to increased regional co-operation within the natural sub-regional areas of the continent (West Africa, Central Africa, East Africa and Southern Africa). According to the CCTA (1956:3), it made possible further studies on strictly regional problems, which included soil conservation, land utilisation and the scientific aspect of geology. Above all, Davis (1982:8) argues, "the institutions developed for colonial research were innovations in the sense that serious research in tropical and subtropical environments would have been impossible to without them. Colonial science in colonial Africa was thus not a mere imitation of metropolitan science, but was the development of bodies of knowledge about aspects of the environments which were more or less unfamiliar to European science at the time". However, a major weakness of CCTA/SCA was that it lacked financial resources and did not have its own regional research infrastructure. It had to rely on the magnanimity of the various governments for financial and infrastructure support.

3.2.6.7 Institutional funding

Finance for research and for the mobility of scientific workers is vital for the proper functioning of international co-operation. Therefore, in order to facilitate these two main issues and make the CCTA/CSA programmes and activities more effective, the CCTA created the Inter-African Research Fund and the Inter-African Research Foundation for the Exchange of Scientists and Technicians. The Inter-African Research Fund was an arrangement whereby projects could be financed by the government in agreed proportions, perhaps with contributions from other external sources, but it used the CCTA/SCA secretariat as its administrative agent (Worthington, 1958:55). The first project financed jointly under this agreement was an African Climatological Atlas and the second a comprehensive book *Science in the Development of Africa* (particularly colonial scientific activities) by Worthington, published in 1958 after Lord Hailey's *African Survey* (1957).

Furthermore, the creation of the Inter-African Foundation for the Exchange of Scientists and Technicians in 1955 added momentum to scientific co-operation. This was prompted by the recognition that one of the best ways of ensuring mutual assistance between scientists and technicians is for them not only to meet each other for discussions on common problems, but also to work for certain periods in each other's laboratories. The details of the Foundation's programme allowed the individual scientist a free hand to undertake his work at any centre to which he may be allocated. As the Commission noted, given that the conditions in the continent vary so much from one part to another, it was wiser to encourage technicians and research workers to make their own recommendations rather than to enforce upon them the "dictates" of an inter-governmental bureaucracy whose outlook was alien to them (CCTA, 1956:2). This was, however, based on the condition that the scientists made available the results of the research to the Foundation.

In budgetary terms there was a dual approach to the provision of funds to these regional organisations under the CCTA, including the CSA. Owing to the differences in the administrative and the political set-up of the six governments, in some instances the contributions came from the individual territories, while in others they came from the member government themselves. For example, South Africa, Southern Rhodesia, France and Portugal contributed as governments. However, the United Kingdom and Belgium asked their territories to contribute to the costs of these various organisations. During the early years of CCTA and the CSA the total cost of these various Inter-African Technical Organisations, as they were called, stood just above £70,000 a year (Henry, 1953:313), while the total budgetary allocation or the central operating budget of the CCTA ranged from £150,000 from the late 1950s to £284,000 in 1965 (Gruhn, 1967:69).[17] In fact about $175,000 of the small budget in 1952 went to the six permanent bureaux and services under the auspices of the CCTA and related activities of the CCTA/CSA (Davis, 1982:104). The attainment of independence by Ghana in 1957 and its admission together with Liberia as members in 1958 changed the composition of payments. In subsequent years, until 1965, all the territories that gained independence also became paying members.

Furthermore, in view of the differences in the economic capabilities of the members both old and new, there was also a dual budgeting system according to the percentages contributed by members to the central operating fund. The original six members' percentage assessment was based on factors such as the extent of their involvement in Africa and the size of their national budgets; but often the final decision was based on mutual agreement among the six. The percentages paid by the newly independent African members were based on their United Nations contribution criteria. For example, in 1958, of an estimated £147,552 budget, the contributions of members were distributed as follows: Belgium £24,262 (16.5%), Federation of Rhodesia and Nyasaland £7,382 (5.0%), France £29,534 (20%), Ghana £7,382 (5.0%), Liberia £7,382 (5.0%), Portugal £17,718 (12%), Union of South Africa £24,362 (16.5%) and the United Kingdom £29,530 (20.0%) Larger projects were separately funded either through

[17] In terms of US dollars, by 1965 the total budgetary allocation was estimated at $700, 000 (Davis, 1982:117).

members or by donors (Gruhn, 1967:85-86).[18] By 1965 the CCTA had transformed itself in name and membership, consisting of 34 African countries, with the bigger contributions coming from the United Arab Republic (12.5%), Nigeria (10.5%), Morocco (7.0%), Algeria (5.0%), Ghana (4.5%), Congo Leopoldville (3.5%) and Sudan (3.5%); the rest contributed less than 3% each (Gruhn, 1967:88).

However, the withdrawal of South Africa, Portugal and Rhodesia in 1962 reduced the financial resources of the CCTA/CSA. This was coupled with the delayed payment of full contributions or non-payment of the full amount.

3.2.6.8 Analysis

Despite these good intentions of the inter-territorial and colonial co-operation programmes, "[m]ost Africans did not derive significant benefits from the scientific research infrastructure created in the colonial period; they were spectators to the scientific development of their countries. Scientific human resources were imported to staff the territorial and inter-territorial scientific services in Africa" (Eisemon *et al.*, 1985:196). This was because facilities for the scientific training of Africans were not established until shortly before independence in British and French Africa. The colonial administrations in Africa did not even help Africa build its own scientific and technological capability, even for the sake of increasing and improving its basic food crops (Okigbo, 1991; see also Gaillard, Krishna & Waast, 1997; Eisemon, Davis & Rathgeber, 1985).

Coupled with the above was the fundamental error of the colonial leaders in believing that the CCTA/SCA was apolitical and not a political tool, and could therefore be used as a mechanism to prevent the United Nations agencies from participating in the transformation and development of Africa (i.e. the CCTA/CSA was considered an apolitical institution, but it showed how scientists often neglected the political implications of their activities, whether wittingly or unwittingly). But such tactics could not be maintained as some of the newly independent African countries became wary of the intentions and purposes of FAMA and the CCTA (see Davis, 1982; Gruhn 1967).

[18] The contributions of Belgium, France and the United Kingdom were not part of their individual commitments to their colonies and former colonies in Africa. CCTA never got its full budget paid in the 1960s (for details, see Gruhn, 1967).

3.3 NATIONAL SCIENCE AND TECHNOLOGY

Between 1960 and 1990 scientific development in Africa entered what can be termed a *national* phase of development. Gaillard, Krishna and Waast (1997:31) note that *national* science "signifies the conceptualisation of scientific research in the broader interests of the country's socio-economic framework". Thus, efforts are made to indigenise scientific institutions and research is conducted predominantly by local citizens. According to them, the agenda of research at both the macro and meso levels is not dictated by remote centres of metropolitan imperial agencies but by the country's decision-making process (see also Waast, 2001).

In this period Africa saw the introduction of national S&T policy frameworks, the cultivation of national systems of innovations (NSIs), and the creation of mostly state-funded institutions whose main focus was the particular developmental needs of the particular state. As part of this nationalising and indigenising of S&T, attempts were also made to transform trans-border co-operative institutions from the colonial era into truly African (and pan-African institutions) (Nel & Teng-Zeng, 1999). In other words, this is the phase during which the newly independent states were/are to establish more independent scientific traditions, including academies of science, national research councils, science commissions, governmental committees or research institutes. According to Basalla (1967:617), all societies that were dominated by colonial science often sought the establishment of an independent national tradition and institution of science after gaining political freedom. Thus, "[a]fter the American Revolution there was nationalistic sentiment in the new nation which encouraged the building of an American science upon native foundation". Similar sentiments also appeared in the South American colonies after they broke with Spain.

Basalla further notes that, for instance, Andrés Bello, a Venezuelan thinker and philosopher, in 1848 called for a South American science which bears the stamp of its national origin, that would not be "condemned to repeat servilely the lessons of European science" (Basalla, 1967:617). This was exactly the sentiment in Africa and, as Davis (1982:19) puts it, there was a move towards the "decolonisation" of science and scientific research in Africa from 1960 onwards. For example, some of the first countries to gain independence in Africa – such as Egypt, Tunisia, Ghana and Guinea – set up their own science policy-making bodies to expand existing R&D networks through effective policy-making and implementation. Hence all the

African territories which later gained independence set up their own science councils to promote scientific and technological development.

Early efforts were also directed towards the provision of scientific infrastructure, particularly universities and technical institutions for the training of scientists and technicians, as well as the establishment of research institutions. In the area of manpower training, for example, following the Addis Ababa Plan a commitment was made by African universities /governments in 1961 to ensure that higher institutions of learning admitted 60 percent (from 1965-80) of the student population in science, technology and engineering courses (Forje, 1989:76).[19] This was prompted by the findings that emerged in studies conducted in 1961/62, where the proportion of student enrolment at tertiary institutions was estimated at 34.6 percent of the total number of students in the sciences in Africa. That included science, 16.2 percent; engineering and architecture, 6.5 percent; medical sciences (including pharmacy and dentistry), 7.3 percent; veterinary science, 0.7 percent, and agriculture and forestry, 3.9 percent, while other fields of studies represented 65.4 percent (UNESCO, 1963:24).

Furthermore, although agriculture, forestry and fishery formed the backbone of the colonial administration and economy, they were among the neglected areas. In West Africa, for example, despite agriculture being the mainstay of their economies, between 1952 and 1963 only 150 university graduates in agriculture were in the Anglophone countries and only 4 in French-speaking countries (Forje, 1989:70). In British East Africa, of the 80 sub-regional research officers in service in 1961, 78 were expatriates, one Asian and one African (see Eisemon & Davis, 1997:110). Training courses were even more rare until the creation of FAMA in 1958. In 1959 FAMA proposed to member governments that short training courses in veterinary medicine be held, some for senior officials and others for middle-level personnel (Davis, 1982:120). Hence Davis (1982:21), argues that for many years following independence research activity was virtually synonymous with the presence of expatriates in many national or sub-regional research institutions. The problem as indicated by another study is that, although the percentage of expatriate researchers, for instance in Sub-Saharan Africa, decreased roughly from 90% between 1961-1965 to 29% between 1981-1985, the absolute number has not been reduced. Rather, there has been an increase from 1200 expatriates in the agricultural sector in 1961-1965 to 1400 in 1981-1985 (Pardey, Roseboom

[19] The targets were set for Middle Africa and North Africa for 1965-1980. For 1965: Middle Africa 4,400 and North Africa 26,000 representing 40%; for 1970, 9 900 and 40,000 (45%); for 1975: 23, 000 and 56, 000 (50%) and for 1980: 59, 000 and 83, 000 (60%).

& Anderson, 1991a:223; Pardey, Roseboom & Anderson, 1991b:288).[20] Africa has not been able to achieve the 60 percent target and is still lagging far behind in the developed countries and most developing areas. Again the agricultural sector is a clear example. Current statistics show that there are 42 researchers per million in the economically active population in agriculture in Sub-Saharan Africa as compared with an average of 2458 researchers per million in the developed counties (Paarlberg, 2000:36).

Meanwhile, in the course of time, and as the fiscal problems of African states became ever more daunting, co-operative efforts increasingly played second fiddle to national systems of innovation (NSIs) and their ever-growing needs. These trends became particularly prominent in the 1980s and, as the decade wore on, state-sponsored S&T co-operation on the African continent stagnated or deteriorated (Nel & Teng-Zeng, 1999).

In other words, the ideal of "deep" co-operation in science and technology could not be sustained after most of the colonies gained independence and broke up into small national units. They lacked the critical mass of experienced scientists and were unable to attract and retain first-class scientists (Odhiambo, 1991). In addition, the former territorial institutions, which had served different territories as we noted earlier, were taken over by the newly independent countries and sub-regional headquarters became national centres. In 1962 the West African Research Organisation (WACRO), which co-ordinated all the regional network of research institutions in British West African colonies, was dissolved. Similarly, the East African Agriculture and Forestry Research Organisation (EAAFRO) was dissolved in the 1970s. The West African Cocoa Research Institute at Tafo in Ghana became a national institution, while others such as the West African Rice Research Institute in Sierra Leone and the West African Research organisation collapsed or dissolved.

In the 1960s there was increased interest in the annexation of former inter-territorial institutions in SSA. In 1960 the CCTA/SCA itself announced that it had "moved forward from the stage of being a colonial organisation to that of constituting a regional association of African countries" (CCTA/SCA 1960, as cited in Davis, 1982:116). It should be noted that the inclusion of Ghana, Liberia, Guinea and Cameroon by 1960 started the process of the decolonisation of CCTA. However, it was at its seventeenth session held at Abidjan in February 1962 that the nomenclature of the CCTA was changed by deleting the words "South

[20] This excludes the Republic of South Africa.

of the Sahara" from the Commission in order to broaden its geographical scope.[21] To achieve this the Secretary-General of the Commission was requested to "awaken the interest of the Governments" of Ethiopia, Sudan, Togo and the North African region in the Commission's activities. Similar steps were also taken by CSA at its thirteenth meeting in September in the same year at Muguga, Kenya, while steps were to be taken "to cease all relations with South Africa and Portugal" (CCTA, 1964 as cited in Odhiambo, 1996:78).

Furthermore, in the early 1960s the increase in technical assistance from the United Nations agencies in Africa also forced the CCTA/SCA to shift most of its activities to these agencies. For instance, education was shifted to UNESCO, economics and statistics to the Economic Commission for Africa, tropical diseases to the World Health Organisation and agriculture to the Food and Agricultural Organisation (see Davis, 1982:117).

At the same time there was an interest among the international institutions, particularly the United Nations and its specialised agencies, in promoting both national and regional capacity building in S&T. As such, a number of international and regional conferences were held to promote the idea of co-operation as well as NSI in developing regions for which Africa is part of. The most notable ones include:

- The United Nations Conference on the Application of Science and Technology to the Development of Less-Developed Countries, Geneva, Switzerland, 1963;
- The International Conference on the Organisation of Research and Training in Africa in Relation to the Study, Conservation and Utilisation of National Resources, 28 July to 6 August, 1964, Lagos, Nigeria;
- Symposium on Science Policy and Research Administration in Africa, 10-12 July 1967, Yaounde, Cameroon;
- The Regional Symposium on the Utilisation of Science and Technology for Development in Africa, 5-16 October 1970, Addis Ababa, Ethiopia;
- The Conference of Ministers of African Member States Responsible for the Application of Science and Technology to Development (CASAFRICA I) 21-30 January 1974, Dakar, Senegal;

[21] Gruhn (1967) notes that Ghana had argued that the geographical purview of the CCTA/CSA should cover the whole of Africa, which led to the temporary suspension its membership in 1960/61 but it rejoined in 1962.

- Technical Co-operation among Developing Countries (TCDC), 1978, Buenos Aires, Argentina;
- The United Nations Conference on Science and Technology for Development (UNCSTD) 20-31 August 1979, Vienna, Austria;
- The Lagos Plan of Action for the Economic Development of Africa (1980-2000) April 1980 Lagos, Nigeria;
- The Second Conference of the Ministers of African Member States Responsible for the Application of Science and Technology to Development (CASAFRICA II) 6-15 July 1987, Arusha, Tanzania;
- Abuja Treaty for the Economic Community of Africa and its Protocol on Science and Technology, 1991, Abuja, Nigeria;
- The First African Regional Conference on Science and Technology (ARCST), 4-9 November 1995, Addis Ababa, Ethiopia;
- World Conference on Science for the Twenty-First Century, 26 June to 1 July 1999. Budapest, Hungary.

At the close of these conferences the emphasis was placed on the importance of NSI as well as on the post-national drive towards reaping the benefits of sustainable development through S&T. This led Davis (1982:19) to conclude that "[t]he problematic of the decolonisation of scientific research in modern Africa is related to domestic as well as international factors" as these conferences helped to direct efforts at scientific and technological development. However, the activities of these organisations focused more on bilateral assistance than on regional institutions, even though the conferences often reiterated the need for regional co-operation within the period from 1960-1990. The present state of scientific and technological backwardness in Africa can be attributed to the collapse of sub-regional and regional institutions during this phase.[22] Hence the renewed interests in regional and international S&T co-operation.

[22] Interview with Dr Benjamin Ntim UNESCO South Africa Office, Pretoria, 5 June 2000.

3.4 POST-NATIONAL PHASE[23]

In May 1963, at a Summit Conference of independent African states held at Addis Ababa, it was decided that a Scientific, Technical and Research Commission (STRC) should be established. Resolution VII of the Summit stated that the CCTA could be adapted to fulfil that role. However, it was not until June 1964 that a tentative decision was taken by the newly formed OAU Council to integrate the CCTA with the OAU. It was suggested and accepted by the African members of CCTA that in future the CCTA should receive technical and financial assistance within the parameters of existing technical programmes (Nworah, 1979:60).

The CCTA and the CSA were transformed in 1965 into organs of the Organisation of African Unity (OAU), where the CCTA became the Scientific, Technical and Research Commission (STRC) and the CSA became the Scientific Council of Africa (SCA), as the science advisory body. This means that regional co-operation in Africa started early with a mechanism for scientific and technological co-operation. In fact, Article II Sub-section 2 of the OAU Charter on co-operation emphasised that member states shall co-ordinate and harmonise their general policies, including scientific and technical co-operation.

Within the OAU scientific and technological co-operation falls under the Department of Education, Science, Culture and Social Affairs (ESCAS). ESCAS has five Specialised and Technical Offices, based in Lagos, Nairobi, Conakry, Ouagadougou and Yaounde to help it promote and co-ordinate the application of S&T for development in Africa.

However, participants at a Lagos Conference in 1964 felt that regional structures for scientific co-operation could be achieved in the near future. At the CASTAFRICA I conference in 1974 participants favoured a cautious, incremental approach to regional co-operation. But the 1979 African Regional Paper for UNCSTD urged African states to formulate and adopt "an integrated economic and technological development policy" (UNCSTD, 1979). This Paper was later incorporated into the 1980 OAU-sponsored Lagos Plan of Action (LPA) for the Implementation of the Monrovia Strategy for the Economic Development of Africa (OAU, 1980). Therefore, the LPA duly included a chapter on science and technology and, according to Boneachenhou (1982), it presents the first attempt at

[23] The account of this fourth phase relies heavily on the work of Nel and Teng-Zeng (1999) and Teng-Zeng (1999).

formulating a comprehensive science plan for Africa within the framework of a strategy for economic development involving the creation by the end of the century of an African Economic Community, collective self-reliance and control of foreign actors (see Eisemon *et al.,* 1985:200).

However, Odhiambo (1991) notes that the STRC (based in Lagos), which was to assist in the implementation process, was little known outside a small circle of dedicated specialists and governmental planners in Africa as it lacked presence and credibility. Its advice rarely drew attention and therefore it ceased to be an effective inter-governmental organ for technical co-operation in Africa. The Scientific Council of Africa (SCA), which replaced the CSA as the science advisory body, was similarly unknown and for the whole of the 1980s it met only twice.

As a result the LPA has failed to sever as a guiding document on S&T capacity building for the socio-economic transformation and development in Africa. Nevertheless, interest in regionalism in science has started to resurface in Africa after a low point in the 1970s and early 1980s. In particular, the 1990s were characterised by attempts to breathe some new life into S&T co-operation in Africa. Some examples of this are the resurrection of the CSA after 1994 under the auspices of the OAU/STRC as the main science and technology policy advisory organ of the OAU (Odhiambo, 1996:138). This development comes in view of the effective regional co-operation as envisioned in the Abuja treaty in 1991 for the establishment of an African Economic Community by 2025 to replace the LPA. Under the treaty various policy protocols are needed to foster regional and sub-regional co-operation, including one for science and technology. Initial attempts to set in motion a process to have a draft protocol discussed and ratified have so far not been successful (the 1991 Treaty is examined in more detail in Chapter Five).

Co-operation was also taken further in 1994 with the creation of the African Foundation for Research and Development (AFRAND) in the course of the second annual session of the Presidential Forum on Management of S&T for Development in Africa. The headquarters of AFRAND are based in Lilongwe, Malawi. It has created three bodies as mechanisms to enhance co-operation and development of S&T in Africa:

- the Roundtable of Science Advisors for Science-led Development in Africa;
- the Roundtable of Technology-Oriented Entrepreneurs in Africa; and

- the Roundtable of Capacity-Building Leaders in Africa.

Part of FRAND's programme covers Distressed and Expatriate Scientists and Scholars from Africa and is aimed at mobilising African brainpower resources world-wide. AFRAND initiated programmes in 1995 to raise funds, most of which would be invested as an endowment fund with the income used for support for projects deemed as having strategic importance to Africa (Odhiambo, 1996:141).

Other regional efforts that have been undertaken over the years in the scientific and technological fields include African Remote Sensing, with its headquarters in Burkina Faso, environmental studies undertaken by the Lake Chad Basin Development Authority, the African Standards Organisation in Ghana, and the Union of National Radio and Television Organisations of Africa (URTNA), which was created in 1962 and based in Senegal. Also in existence are the Pan African Documentation and Information System (PADIS) for documentation based in Ethiopia under the auspices of the Economic Commission for Africa, and the African Regional Centre for Engineering Design and Manufacturing in Ibadan, the African Institute for Higher Technical Training and Research in Nairobi, and the African Regional Centre for Technology in Dakar, all for engineering and technology (Cunningham & Barker, 1992:121; Forje, 1989; Teng-Zeng, 1999). Some of these have sub-regional centres, e.g. Remote Sensing, which has centres in the Democratic Republic of Congo, Egypt, Nigeria and Kenya (see Nel & Teng-Zeng, 1999). However, some of organisations have been completely dormant, but in order for Africa not to be marginalised in the knowledge-driven global economy, there is a renewed sense of urgency to revive and sustain their programmes.

Furthermore, efforts at the regional level need to be complemented through sub-regional institutions. Therefore, at the sub-regional level several co-operation programmes were initiated through the sub-regional economic groupings. For instance, in 1979 the West African Economic Community adopted an additional protocol to its constitution relating to the promotion and implementation of a policy for S&T. Cunningham and Barker (1992:123) assert that "the objective of the protocol was the promotion of the economic and social development of member states through scientific progress and technological innovation" (see also Forje, 1989). This protocol led to the formation of the West African Rice Development Association to improve the production of rice.

With support from United Nations Development Programme (UNDP) and the United Nations Industrial Development Organisation (UNIDO), Central Africa also set up a specialised institution: the Sub-regional Multisectoral Institute of Applied Technology, Planning and Project Evaluation (ISTA) in 1980. In addition, the Southern African Development Community (SADC) formulated research strategies for the sub-region under its Rome Declaration on Research and Development in the Region. This included the establishment of an institutional infrastructure for promoting and co-ordinating research, documentation and information exchange. A more recent approach to sub-regional co-operation is the *Southern African S&T Exchange Programme*, a proposal developed by the Commonwealth Science Council (CSC) in 1997. This was based upon a request to the CSC by both the government of South Africa and the ECA for the CSC to develop a programme that could lead to the exchange of S&T experts, researchers and teachers in southern Africa (Abiodun, 1998:40). It is envisaged that the beneficiaries, which include Lesotho, Mozambique, Swaziland and Tanzania, can take advantage of their proximity to South Africa with "its well-established institutions, to improve their S&T infrastructure and enhance their human capacity". One of the programme's core objectives is the creation of self-reliance among these countries (see Teng-Zeng, 1999).

According to Nel and Teng-Zeng (1999), the most important feature of this fourth phase in the evolution of S&T in Africa is perhaps the renewed attempts by most stakeholders to place regional co-operation on a surer footing. For them, what makes this era significantly different – and constitutes it as a truly *post-national* era – are the following:

Firstly, the introduction of structural adjustment programmes in a number of SSA countries has had contradictory results for the development of S&T on the continent. On the one hand, the programmes preferred by multilateral and bilateral donors have in the case of certain states led to an increase in the amount of R&D investment in those countries, despite the fiscal discipline imposed by the SAPs. Part of the explanation is that the acceptance of SAPs has made these states more attractive for foreign donors, and that most of these donors have targeted specific S&T areas where they would like to see their donations being spent. For instance, between 1981/82 to 1991/92 government expenditures on R&D on average changed each year by 22% in Ghana, 9% in Kenya, 4% in Tanzania and Uganda 61%.

While the above increases provided a lifeline for struggling NSIs, they have the effect of undermining the capacity of local policy makers to determine S&T priorities and replacing them with "international" priorities, often geared to the commercial interests of the donors. Such a dilemma has been demonstrated by Enos in his analysis of the *Masterplans* being formulated by most sub-Saharan African countries on R&D priorities and expenditures. In the case of Tanzania's Agricultural Masterplan formulated in 1991, the first priority is given to R&D on "coffee, cotton, tea, rice animal health, soil and water management and 'farm systems' research, in that order".

Secondly, foreign donors such as the World Bank and international bodies such as the World Health Organisation (WHO) have themselves become active participants in the setting up of co-operative projects in Africa. The World Bank, for example, undertook a study in West Africa which led to the West Africa Gasline project. This is aimed at linking Ghana, Togo, Benin and Nigeria to utilise the Nigeria's abundant natural gas currently under-utilised to generate electricity for the other partners. Although on a smaller scale, this project can be likened to the Southern Africa Power Pool project within SADC.

Thirdly, although the data are almost non-existent, it is surmised that multinational corporations are becoming important players in the R&D field in SSA particularly in the agricultural sector. The keen interest of the private sector in R&D in SSA (and other developing countries in general), according to Pray and Echeverria (1991), is stimulated by at least three main reasons. First and foremost, current economic policies in general and structural adjustment policies in particular which advocate market liberalisation and less interventionist stand on the part of governments in all economic activities. Secondly, the private sector is assuming a more active role in research, both basic and applied, related to the development of new biotechnology in agriculture and this in turn is expected to have important repercussions for technology development and transfer in developing countries. Thirdly, a more active role for the private sector is closely linked to international pressures to strengthen intellectual property rights protection related to plants or plant genetic resources (see also Brenner, 1992).[24]

This means that S&T on the continent is also subjected to the increasing commodification and globalisation of knowledge production. The logic of these processes is quite simple: the

[24] However, in the past the low rates of investment in R&D by the private sector in SSA have been attributed to the following factors: a considerable shortfall in knowledge when it comes to production; enterprises that are subsidiaries of multinational corporations carry out R&D in locations outside Africa, there is generally low level of manufacturing activity in the region; the output infrastructure for R&D is poor; and highly trained and qualified R&D personnel are in short supply (Adeboye, 1998:168).

commodification of knowledge leads to the privatisation of knowledge production, which wrenches more and more decision-making responsibility from the hands of the custodians of NSIs, namely states. This process is speeded up by the rapid transnationalisation of S&T activities, driven mainly by the R&D interests of multinational companies, which determine what mode of knowledge production can and should proceed. Despite laudable attempts by some aid donors to assist countries of SSA to adjust to these pressures, the focus of this aid tends to further undermine national authority in favour of a more dispersed authority favouring the commercial interests of the donors. This contributes both to the marginalisation of knowledge production in developing countries, particularly in SSA, and to the undermining of their national policy capacity to explore the otherwise valuable concept of "knowledge for development".

Furthermore, the World Bank's involvement in agricultural and medical research is also helping to mobilise and promote regional and sub-regional co-operation in research and development in Africa. As the host for the Special Programme for African Agricultural Research (SPAAR), the Bank is in a position to further enhance the activities of sub-regional institutions, including the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), Conférence des responsible de Recherche Agronomique en Afrique de l'Ouest et du Centre (CORAF), the Southern African Centre for Co-operation in Agricultural and Natural Resources Research and Training (SACCAR) and recently the Forum for Agricultural Research in Africa (FARA), e.g. the Sub-Saharan Africa Seed Initiative. For instance, in 1990 six common principles were adopted by SPAAR as the Frameworks for Action (FFAs), which include: institutionalising strategic planning process, improving institutional and management capacity, developing sustainable financing mechanism for agricultural research, promoting the establishment of donor consultation groups, strengthening research extension-user linkage and encouraging regionalisation of research.

The lack of a sufficient food supply system in the developing countries prompted the setting up of an international agricultural research centre, the International Rice Research Institute (IRRI) in the Philippines in 1960 by the Ford and Rockefeller Foundations. Then in 1966 the Rockefeller Foundation established, through its programmes, the International Maize and Wheat Improvement Centre (CIMMYT) in Mexico (Coulter, 1984:266). Furthermore, in 1967 a tentative decision was taken by the two Foundations to establish two more institutes, namely the International Institute of Tropical Agriculture (IITA) in Nigeria and the International Centre for Tropical Agriculture (CIAT) in Colombia, which were completed in 1970 and 1971 respectively.

However, the cost of funding these institutions increased enormously and there was a need for sustained long-term funding that would complement these private efforts by the international community and foster co-operation. Hence the emergence of the Consultative Group on International Agricultural Research (CGIAR) in May 1971 at the initiative of the World Bank. The CGIAR was to help broaden the support for international programmes on research and training aimed at increasing the quantity and improving the quality of food production in developing countries. The CGIAR was created as an association of international and regional organisations, national governments, public and private foundations and representatives of developing countries (Coulter, 1984:267).

The United Nations Food and Agricultural Organisation (FAO), United Nations Development Programme (UNDP) and the World Bank together with private Foundations (Rockefeller and Ford) jointly sponsor the CGIAR. The Bank provides the chairman and the executive secretariat. The CGIAR is advised by a panel of experts, the Technical Advisory Committee (TAC), whose secretariat is provided by FAO. The CGIAR has grown steadily, with its international centres increasing from 4 to 16. Of these 16 research centres, 4 are in Africa, seeking to promote regional and international co-operation in agricultural research to enhance food production (see Chapter 4 for more discussion on the World Bank).

Similarly, the WHO's Onchocerciasis Control Programme in West Africa (OCP) has brought river blindness in the Savannah areas of 11 West African countries under control. As a result of this success, the programme has been extended to cover the entire continent as the African Programme for Onchocerciasis Control (APOC), with the World Bank as the fiscal agent. In this they follow an earlier example set by UNESCO; the only and important difference is that these bodies are seemingly much better organised and more successful than UNESCO ever was.

In essence, a landmark in the post-national phase is the support now given to regional programmes by donor institutions, thereby encouraging techno-regionalism. UNESCO, the World Bank, the European Union, Rockefeller Foundation, Ford Foundation, McKnight Foundation, the National Research Foundation of South Africa and a host of other bilateral and multilateral institutions make resources available for transnational co-operation in scientific and technological programmes, a basic feature of the post-national phase is the generation of knowledge for development.

3.5 GENERAL CONCLUSION

From the discussions above we have tried to outline the stages of the development of science and technology. Four phases have been identified: the pre-colonial, colonial, national and the post-national. The main significance of this taxonomy lies in the discussion of the pre-colonial and the post-national phases. This is because most scholarly work on science and technology in Africa, particularly in economics and politics, focuses more on the colonial phase onwards, leaving a consideration of the pre-colonial phase mostly to archaeologists and historians. Others dwell in their analyses on the national phase, even though the trend is towards increasingly trans-national scientific activities.

The colonial phase was marked by an interest in agriculture, in particular crops mainly for export, mineral exploration and exploitation, and developments in tropical medicine. The colonial period further marks the genesis of inter-territorial co-operation and therefore regional institutions in the various territories under the British, French, the Portuguese and the Belgians. The colonial status of the Union of South Africa and Southern Rhodesia presents a different dimension because they were inhabited by settlers from Europe. Hence these two countries had well-developed scientific infrastructures and were able to play a meaningful role in inter-colonial co-operation in science and technology. This saw South Africa becoming the first country to host the African Regional Conference on Science in 1949, whose aftermath saw the establishment of the Commission for Technical Co-operation in Africa South of the Sahara and the Scientific Council for Africa South of the Sahara.

The advent of independence in most the colonial territories, however, witnessed the collapse or nationalisation of the regional inter-territorial institutions at the sub-regional level by the newly independent states. For instance, in British West Africa the West Africa Research Organisation, which was the regional co-ordination body of scientific activities, was dissolved in 1962. Although the one in East Africa lasted for a while longer, the institutional structures collapsed in the 1970s. At the continental level after independence and the formation of the OAU in 1963, the CCTA and the CSA were adopted as regional organs under it to promote scientific and technological co-operation and development in 1965. An important decision had been taken earlier in 1962 by the independent African states to change the geographical purview of both the CCTA and the CSA by deleting the words "South of the Sahara" from their names. But the national and regional efforts in the pursuit of S&T in the 1960s and 1970s as well as the 1980s did not achieve the desired results. Notwithstanding the subsequent development of national research communities in many African countries, Africa is still the region of the world most penetrated by and dependent upon external scientific and technical expertise, resources and research activities.

However, we also admit that delineating the phases of the development of S&T is not easy. While it may be possible to separate the colonial era, the national and post-national phases are more of a problem; however, programme formulation and implementation serve as guiding principles to help us differentiate the various phases.

The lack of progressive development of S&T at the national and regional levels has meant that the competitiveness of Africa as well as its contribution to world science has deteriorated. Amidst this downwards trend there have been renewed calls for regional co-operation in S&T by both international and regional institutions, which makes imperative an evaluation of the roles of these institutions in facilitating co-operation. This is because the success in generating knowledge for development will depend on the way these international and regional institutions can help transform the continent through their programmes to alleviate, hunger, poverty and disease. Hence Chapter 4 discusses some of the international institutions and their programmes on S&T in Africa.

The daunting task, as observed by Nel and Teng-Zeng (1999), is that "attempts by African states to revive inter-state co-operation in S&T coincides with a fundamental shift in S&T production and management from a national to a post-national dimension in which a number of actors, other than states, become important players in the knowledge game. This has deepened the challenge to S&T policy makers in Africa: not only do they have to try and make up for the poor performance of policy formulation and implementation in the national era. They have to do so in circumstances where they are losing the capacity to do so".

CHAPTER FOUR

INTERNATIONAL INSTITUTIONS AND THE DEVELOPMENT OF SCIENCE AND TECHNOLOGY IN AFRICA

4.1 INTRODUCTION

In the aftermath of the Second World War the development challenges facing the Third World countries – those that were independent, those emerging from colonialism and those still under colonialism – led to the proliferation of bilateral and multilateral development institutions. These institutions, as we noted in the previous chapters, were intended to assist the developing countries in terms of the provision of both human and material resources for socio-economic transformation and development. If the enormous development problems facing Africa can be alleviated, then international multilateral development institutions have a major role to play in its scientific and technological development as well as in helping to create the appropriate institutional mechanisms for regional and sub-regional co-operation in S&T in Africa. This is because of the resources (both human and material) at the disposal of these international institutions and of their ability and capacity to mobilise such resources. The United Nations system, including UN-affiliated institutions, has come to represent the best hope of realising the dream of most developing countries in their quest for development, due to its institutional capacity to provide development assistance.

In this chapter three UN agencies are discussed: UNESCO, the World Bank and the Economic Commission for Africa (ECA). The extent of their experience in development over a long period of time has meant that these institutions play important roles in influencing the international development agenda, which may affect Africa. The World Bank Group remains the biggest donor organisation in terms of the funding of development projects and programmes. UNESCO has a leading role as the UN agency whose mandate relates directly to S&T development and peace. The decision to include the ECA in this section is due to the fact that, although it is a regional institution, the ECA's operational mandates are dependent on the approval of the UN General Assembly, which makes it more of an international institution than a regional one. The ECA is also the leading representative of the UN in Africa and therefore able to influence the direction of development policy. Thus, part one of this chapter discusses UNESCO; part two deals with the World Bank; and finally part three is concerned with the United Nations Economic Commission for Africa.

4.2 UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANISATION

4.2.1 The Origins of UNESCO

One of the major UN agencies that deals with issues of science and technology and seeks to promote international co-operation in this field is the United Nations Educational, Scientific and Cultural Organisation (UNESCO). Representatives of 44 governments formed the Organisation on 16 November 1945 in London after the adoption of its Constitution. Technically, however, the Organisation came into being when Greece ratified the Constitution as the twentieth member country and deposited its acceptance at the Foreign Office in London on 4 November 1946. UNESCO took over the activities of both the International Commission on Intellectual Co-operation, which was set up in January 1922, and that of the International Institute of Intellectual Co-operation, founded on 9 August 1925 in Paris, France. These two bodies together were to form the International Organisation for Intellectual Co-operation (IOIC), whose official establishment was prevented by the outbreak of the Second World War, but which would have carried out a similar function to that of UNESCO (Valderrama, 1995).[1]

UNESCO became a specialised UN agency in 1946. This happened after an Agreement between UNESCO and the UN was approved on 4 November 1946 by the UN General Assembly during its October-December 1946 Session in New York. The primary aim of UNESCO, as stated in Article 1 of its Constitution, is to contribute to world peace and security by promoting collaboration among the nations through education, science, culture and communication in order to further "universal respect for justice, for the rule of law and for the human rights and fundamental freedoms which are affirmed for the peoples of the world, without distinction of race, sex, language or religion, by the Charter of the United Nations"; to give fresh impulse to popular education and to the spread of culture; to maintain, increase and diffuse knowledge and encourage co-operation among nations in all fields of intellectual activities; and to initiate methods of international co-operation calculated to give

[1] For more details about the activities and actions leading to the formation of UNESCO see Caswell, 1966; Krill de Capello, 1970.

the people of all countries access to printed and published materials produced by any of them.

The main tasks are defined as follows:

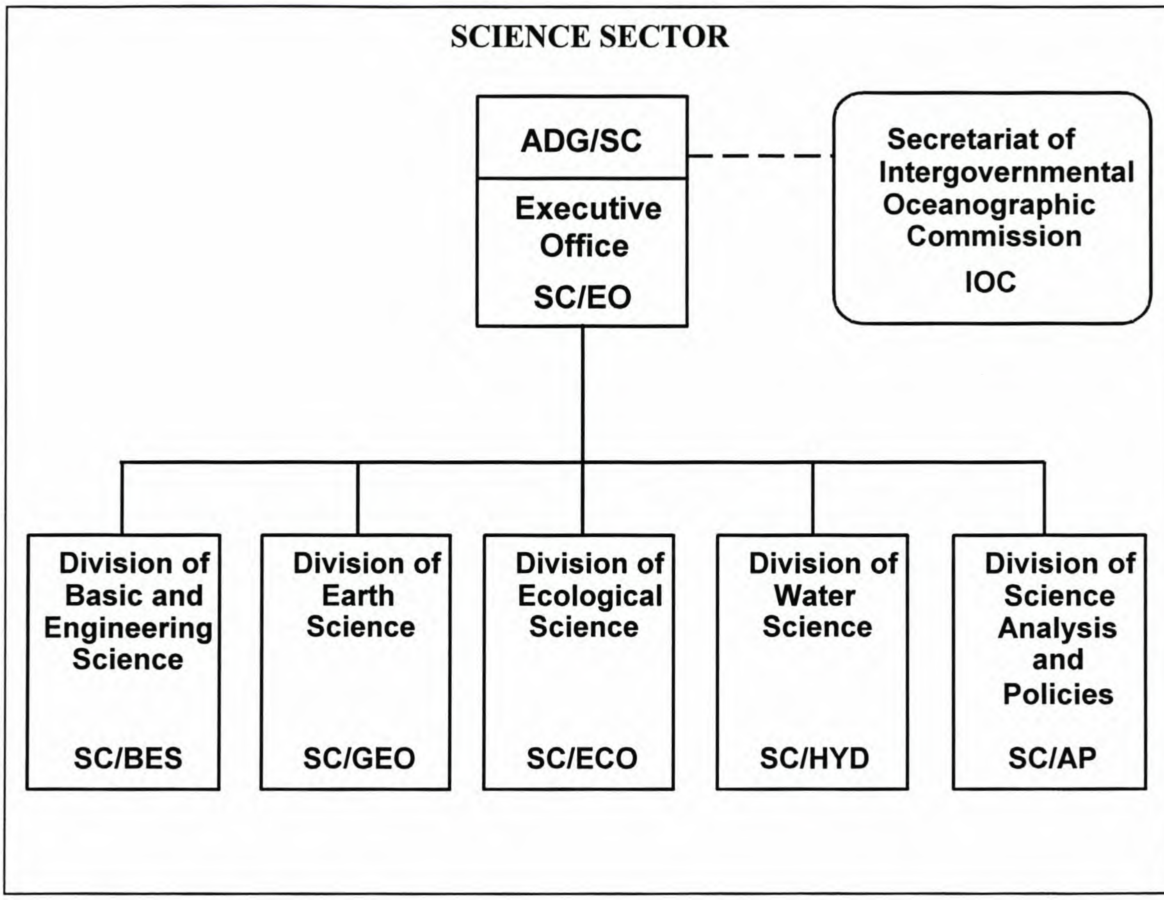
- Contribute to a continuing study of present world problems so as to create a greater awareness of the common destiny which now unites individuals and peoples alike;
- Help to pave the way for the widest participation by individuals and groups in the life of the societies to which they belong and in that of the world community;
- Assist in strengthening problem-solving capability by fostering the development and democratisation of education and the advancement of science, by increasing and developing the creative potential, both scientific and technological, of all peoples by reinforcing aptitudes and abilities, by developing research and training infrastructures and by promoting the free flow of knowledge and know-how;
- Help to facilitate the changes and transitions that are now recognised as necessary by the international community as a whole in fields where the convergence of aspirations gives rise to a broad consensus;
- Arouse and encourage a renewal of values within a context of genuine understanding among peoples, thereby advancing the cause of peace and human rights.

During the 1963-1964 biennium the Education and Science Sectors were created, with the appointment of the first Assistant Director-Generals to head the two sectors on 15 September 1963 for Education and 7 September 1964 for the Sciences, respectively. Education dominated the attention of the Organisation in the early days. However, it was during the General Conference of 1964 that a concrete decision was taken in the Organisation's programme for the 1965-1966 biennium, in which the natural sciences and technology were accorded a degree of importance similar to that given to education (Valderrama, 1995:159). Then, at the General Conference in October/November 1972, various Commissions were established. These included the Commission for Education, the Commission for Science, the Commission for Social Sciences, Humanities and Culture, the Commission for Communication and the Commission for Programme Matters. Besides these, other bodies established were the Resolutions Committee, the Credentials Committee, the Nominations Committee, the Legal Committee, the Headquarters Committee and the Administrative Commission (Valderrama, 1995:270).

The Director-General, who is normally elected for a six-year term, heads the UNESCO Secretariat. The Director-General is often assisted by eight Assistant Director Generals (ADGs), each of whom heads a particular Sector of the Organisation. One of the ADGs heads the division for Natural Sciences and their Application to Development. The others are the Social and Human Sciences and their Application; Education; Culture; Communication and Information; External Relations and Co-operation; and Administration Sectors. Besides these main Sectors there are a number of Bureaux, Offices and Secretariats to handle issues in various areas.

The following divisions currently fall under the Assistant Director-General for Science (ADG/SC): Division of Basic and Engineering Sciences; Division of Earth Sciences; Division of Ecological Science; Division of Water Sciences; and the Division of Science Analysis and Policies (formerly Science and Technology Policies Division). The Sector also hosts the Secretariat of the Intergovernmental Oceanographic Commission. The following divisions have been eliminated as a result of the restructuring of the Organisation: Division of Scientific Research and Higher Education; Division of Technological Research and Higher Education; Division of Marine Science; Operation Programme Division. (See Table 4.1 for a diagrammatic representation of the Organisation's Science Sector).

TABLE 4.1: Structure of UNESCO's science sector



Source: Adapted from UNESCO

The General Conference, which is the supreme governing body of UNESCO, comprises representatives of Member States (189 plus 3 Associate Members, with 173 Member States having established permanent delegations to the Organisation in Paris). The General Conference usually meets every two years to determine the policies and main lines of work of the Organisation and to approve the programme and budget. UNESCO's General Conference also elects an Executive Board of 58 members (up from 51), which acts as the administrative council and meets twice a year. The Secretariat is responsible for execution of the programmes.

In most Member States there are National Commissions consisting of representatives of principal national bodies interested in questions concerning UNESCO, which act as liaison bodies and advise their individual Governments on UNESCO's affairs.

With science enshrined in its name and being the only specialised agency, which deals directly with scientific research, scientific education and the application of science to development and peace, the tasks for UNESCO could not have been more daunting. Therefore, true to its role, the Organisation has taken the major responsibility for addressing the issues of disparities in S&T and strengthening the S&T capability of developing countries through international and regional co-operation. Hence UNESCO is the only UN agency with regional offices for S&T globally. Initially four regional offices, also known as field co-operation offices, were established in 1947 with an office in each of the following areas: Latin America – based in Rio Janeiro (but moved to Montevideo in 1948 through a recommendation after a regional meeting); the Middle East – based in Cairo; East Asia – based in Nankin; and South Asia – in New Delhi (Valderrama, 1995:36). In 1974 it was decided at the eighteenth General Conference that the Regional Science Offices' names be changed to "Offices for Science and Technology" and later to "Regional Centres for Science and Technology". Currently UNESCO has six regional offices promoting national, regional and international co-operation in S&T. These include:

- The Regional Office for Science and Technology for the Arab States (ROSTAS) Amman, Jordan;
- The Regional Office for Science and Technology for Europe and North America (ROSTE) Venezia, Italy;
- UNESCO Office New Delhi, India;
- Regional Office for Science and Technology for Southeast Asia (ROSTSEA) Jakarta, Indonesia;
- Regional Office for Science and Technology for Africa (ROSTA) Nairobi, Kenya, and;
- Office of UNESCO Representative (Science and Technology) in China in Beijing, China.

In order to decentralise its activities an important step was taken during the period of the 1981-1983 triennial to establish posts for regional co-ordinators, whose duties were co-operation with member states, for regional matters and for co-ordinating the Organisation's activity (Valderrama, 1995:270). According to Desai (1997:90), the creation of the Regional Centres and the Commissions has led to an enhanced relationship between the headquarters and the Commissions and to decentralisation of UNESCO's activities. The benefits of this include:

1. A net increase in the number of regional technical assistance projects and regional projects as a percentage of all UN Technical Assistance projects;

2. The expansion of professional staff resources in the regional economic Commissions;
3. The development of a system of regional advisers;
4. The creation of technical assistance co-ordinating units in the regional secretariats;
5. The adoption of a revised set of operational procedures for regional projects, which enlarges the authority of the regional secretary in the implementation of technical assistance projects.

In general UNESCO's contributions to S&T policymaking and the promotion of scientific programmes in the developing World has been very important, but the impact of such programmes has yet to be critically evaluated, particularly in Africa. As we have noted already, UNESCO's policy promotion is based on the principle that, first and foremost, nations must build up an autonomous decision-making capacity in science and technology in order to be able to select their priorities according to their national development objectives. This applies to scientific research, technological transfer from abroad and the whole range of scientific services that must promote the application of new knowledge to all relevant sectors of the economy. UNESCO also insists upon the mutual benefits to be derived from international co-operation, exchange of scientists and free flow of scientific and technological information. Last but not least, UNESCO emphasises to policy-makers the need to enhance the status of scientific researchers, the most important components of the machine, so that they can enjoy satisfactory intellectual and material conditions (Behrman, 1979:52). There was an attempt to render assistance to regional sub-groupings such as the Andean countries adhering to the Adres Bello Convention, or the Economic Community of West African States, to help them establish common policies for applying science and technology (Behrman, 1979:52). In essence UNESCO also pioneered the organisation of regional ministerial conferences on the application of science and technology to the principal developing regions of Latin America, Asia, Africa and the Arab states (see UNESCO, 1979).

4.2.2 UNESCO in Africa

Since its establishment in 1945 UNESCO has had a great impact on the development of the African continent on various fronts, including those of culture, education and S&T. The relationship between UNESCO and African countries is both bilateral and multilateral. As we have already stated, UNESCO argues that each country should build up an autonomous decision-making capacity in science and technology to enable it to select priorities according to its overall development objectives. Bilaterally, therefore, UNESCO's activities cover programmes and projects between itself and individual African countries. For example, new institutions such as planning bodies, government departments or national councils for science and technology were set up in most countries, through the advice and encouragement of UNESCO, during the national phase of scientific institutional capacity building in Africa. Countries such as Kenya, Nigeria, Senegal, Sudan, Tanzania, and Burkina Faso were among the first recipients of UNESCO's technical advice (Behrman, 1979:52).

UNESCO's General Conference at its fourteenth session in Paris (1966) reiterated, through Resolution 2.11, the importance of this national capacity building in S&T. Specifically, Resolution 2.11 subsection (C) authorised the Director-General of the Organisation "to assist Member States in the initiation and improvement of their national science policy planning, in the organisation of their national science research and in the assessment and development of their national scientific and technological potentials with particular reference, as far as Member States in Africa (...) are concerned, to the 'Outline of a Plan for Scientific Research and Training in Africa' adopted by the International Conference on the Organisation of Research and Training in Africa in Relation to the Study, Conservation and Utilisation of Natural Resources (Lagos, 1964) ..." (UNESCO, 1966:41-42). It was the implementation of this resolution that led to the organisation of the first inter-tropical African "Symposium on Science Policy and Research Administration in Africa" at Yaounde from 10-21 July 1967 under the auspices of UNESCO. The main purpose of the meeting was to hasten the establishment of governmental science policy structures, as well as to increase the efficiency and effectiveness of existing scientific institutions (UNESCO, 1969:7).

Odhiambo (1967:880) emphasised the above view on the necessity for national capacity building on S&T, pointing out that the development of an effective advisory agency in the scientific field was of high priority to UNESCO in the 1960s. This, he notes, was due to the fact that by 1966 very few countries in Africa had either national (or regional) academies of science (those that had included Ghana and East Africa) or national research councils or their equivalents (such as Egypt, the two Congos, Cameroon and Senegal). Hence, at the 1966 fourteenth session of the UNESCO's General Council in Paris, the Director-General was requested to initiate or stimulate action in that direction

At present UNESCO has 24 operational offices situated in the following countries: Angola, Benin, Burkina Faso, Burundi, Cameroon, Central African Republic, Congo, Côte d'Ivoire, Democratic Republic of the Congo, Ethiopia, Gabon, Ghana, Guinea, Kenya, Mali, Mozambique, Namibia, Nigeria, Rwanda, Senegal, South Africa, United Republic of Tanzania, Zambia and Zimbabwe. However, following the change of leadership of the Organisation from Federico Mayor to Koichiro Matsuura as the new Director-General, UNESCO is to scale down the number of field offices in Africa from 24 to 11. As a result the field offices in Angola, Côte d'Ivoire, South Africa and Mozambique are due to be closed down permanently.

It should be noted that UNESCO's operations would cover all fifty-three countries in Africa, which means that, as previously, some field offices will serve two or more countries as well as representing UNESCO at the regional and sub-regional Organisations. For example, the Zimbabwean Office represents UNESCO at SADC, the Nigerian Office represents it at ECOWAS, and the Ethiopian Office represents it at the OAU.

In the multilateral sense the Organisation's activities cover programmes and projects in Africa at the regional and sub-regional levels aimed at fostering co-operation between it and other sub-regional and regional institutions to promote co-operation, development and integration. For instance, as early as the late 1970s, UNESCO offered assistance to the Economic Community of West African States to help them establish common policies for applying science and technology (Behrman, 1979:52). The relationship is also international, as UNESCO programmes and activities help promote co-operation between Africa and the rest of the international community that provides opportunities for socio-economic development. These are due to its insistence upon the mutual benefits to be derived from international co-operation, the exchange of scientists and the free flow of scientific and technical information (Behrman, 1979). At the inter-institutional level a Co-operation Agreement between UNESCO and OAU was signed in 1968 and at the 1999 OAU Heads of State and Government Summit in Algiers (Algeria) the OAU called on UNESCO to revise and strengthen the Agreement.

During its twenty-first General Conference in 1980 regional and international programmes were approved for Africa, the Arab States and Latin America. It was not until 1985, at its twenty-third General Conference held at Sofia (Bulgaria) that the Director-General was authorised to prepare and implement a Special Programme of Assistance to Africa in the field of Scientific Research and Research and Development as well as to ascertain, in collaboration with the authorities of the African member states, appropriate ways and means of implementing that programme. The DG was also invited to convene a Regional Conference of Ministers Responsible for the Application of Science and Technology to Development in Africa (Valderrama, 1995:298; UNESCO, 1989). Subsequently, the Conference was held at Arusha, Tanzania. In view of the special situation of Africa, where a large majority of least developed countries (LDCs) are located (28 out of 42 LDCs are in Africa), a Unit was created to co-ordinate the activities of UNESCO in 1989. The Unit formulated (or developed) a special programme known as Priority Africa, which contains practical recommendations for solving problems and meeting the development needs of Africa. The main commitments of UNESCO's S&T in Africa are:

- To advance science and technology by improving the quality of education and high-level research;
- To promote scientific and technological literacy for all;
- To apply the fruits of science and technology to real-world problems;
- To link sustainable development to integrated approaches to environmental management.

To further enhance its operations and to meet the development needs of Africa rapidly through the UN system, UNESCO established the Priority Africa Department in April 1996 following its conference in Paris, dubbed Audience Africa, in 1995. In fact, the Department now provides support to the programme sectors to help them identify, devise and promote projects in Africa. It also seeks new partnerships with a view to mobilising extra-budgetary resources, monitors and follow-up to decisions taken at summits and major conferences in respect of development in Africa. It also co-ordinates all co-operation between UNESCO and African Member States, and inter-governmental and non-governmental African organisations, at both the regional and sub-regional levels.

Furthermore, Audience Africa in 1995 can be said to mark the beginning of a new dynamism in the relations between UNESCO and Africa. The organisation now considers the African region as one of its four main targets for priority attention and action. The remaining three are women; young people; and other least developed countries. Together, the recommendations of the Audience Africa and the UN Special Initiative for Africa (UNSIA) form the core of UNESCO's programmes, which now guide its framework of operations for Africa. Among others, the areas of priority include:

- Regional integration and co-operation and the establishment of regional and sub regional networks;
- Basic education for children in Africa;
- Science and technology;
- Activities concerning the culture of peace;
- The role of African women and youth in the development of the continent.
- To link sustainable development to integrated approaches to environment management.

The main commitments of UNESCO through the development of S&T are:

- To provide advice on S&T in improving the quality of education and high-level research;
- To promote scientific and technological literacy for all;
- To apply the fruits of S&T to real world problems.

It would therefore not be overstating matters to say that Africa is currently the most prioritised region, given that two-thirds of the world's least developed countries are in Africa.

4.2.3 UNESCO and S&T Co-operation Development in Africa

The building of the scientific and the technological capacity for national and regional development in Africa has long been part and parcel of UNESCO's development plan for the African continent. In various ways, through conferences, seminars, workshops and training programmes, it has worked towards facilitating the building of a national system of innovation in different countries as well as encouraging regional and sub-regional initiatives. Out of the 24 UNESCO offices in Africa, four specifically deal with scientific and technological development and co-operation in Africa. These offices are:

- Nairobi (Kenya) which is the main regional office;
- Pretoria (South Africa) for the SADC region;
- Lagos (Nigeria) for the ECOWAS region;
- Tunis (Tunisia) for the Arab Maghreb region.

Meanwhile, following the restructuring of UNESCO and the proposed reduction of the number of field offices in Africa to eleven, the Pretoria Office in South Africa will be closed and moved to Namibia (based on the participation of the Pretoria government in allowing such a move).[2] However, the Science Section will be transferred to Zimbabwe and therefore the UNESCO Office in Zimbabwe will be in charge of science in the SADC region. This is because Zimbabwe has a better S&T infrastructure than exists in Namibia.[3] It is hoped that this will make for more effective and efficient co-ordination.

According to UNESCO, various programmes are usually planned for periods of two to six years, depending on their identified priority in importance to Africa and the amount of interest expressed by Member States. Since Audience Africa the following programmes are being supported, amongst others:

- Improving the learning opportunities available to marginalized youth (1996-2001);
- Promoting girls' and women's education in Africa (1996-2001);
- Scientific, technical and vocational training for girls in Africa (1996-2001);
- Biotechnologies in the service of development in Africa (1996-2001);
- Women, science and technology (1996-2001);
- Arid and semi-arid land management (1996-1999);
- Women, water supplies and the use of water resources in sub-Saharan Africa (1996-1999);
- People's education programmes in West African museums (1998-2001);
- Itinerant African college on culture and development (1998-99);
- Training craftswomen in Southern Africa (1998-199);
- Enhancing training in communication in Africa (1996-1999);
- Women talk to women (development of community radio) (1996-1999)
- Video libraries for young people in Africa (1996-1999);
- Educational software for the teaching Informatics in Africa (1996-2001);
- Women and the culture of peace in Africa (1996-1999);

[2] Discussion with Dr B Ntim, UNESCO Office, Pretoria.
[3] Discussion with Dr Benjamin Ntim, Science Advisor, UNESCO Office, Pretoria, South Africa.

- Strengthening national statistical information systems on education (SISED) in sub-Saharan Africa.

4.2.4 UNESCO Biotechnology and Microbiology Programme

As we stated in Chapter 2 of this study, biotechnology is at the cutting edge of the scientific and technological revolution, particularly in the late twentieth century and hence it is a major factor in the knowledge economies of the new millennium. Africa (except for South Africa), however, lacks the necessary technology and capacity and requires the support of the international community.

Building up regional co-operation and local biotechnology capability has been part of UNESCO within the global network of Microbiological Resources Centres (MIRCENs), with the active participation of Regional Offices of Science and Technology for Africa (ROSTA), the Arab States (ROSTAS) and the Latin America and the Caribbean (ROSTLAC), particularly through the increased participation of local academic institutions. During the 1984-1985 biennium two important activities were carried out by the MIRCENs in Africa and Latin America, which involved the institutionalisation of the African Association of Biological Nitrogen-Fixation (AABNF) and that of the Latin American Association of Rhizobiologists (ALAR) in collaboration with the Food and Agricultural Organisation (FAO) and the (UNEP) United Nations environmental Programme (UNESCO, 1986:27).

Two newsletters entitled *MIRCENs* were produced, one for each year of the biennium. Donations of specialised periodicals and documentation valued at 20 000 dollars were supplied to co-operating MIRCEN centres in the developing and least developed countries. Besides this, in this biennium a new quarterly, the *MIRCEN Journal of Microbiology and Biotechnology* was launched to disseminate the results of scientific projects carried out in the MIRCENs, particularly those located in developing countries. UNESCO made subscriptions of 125 to institutions in 78 developing countries (UNESCO, 1986:27).

Ten specialised training courses, were organised at the MIRCENs to disseminate the latest research techniques to some 200 participants from developed and developing countries, which included some 30 participants from the least developed countries. Those of the above activities pertaining to Africa and the Arab States were carried out within the framework of the major regional project in biotechnology and applied microbiology in Africa and the Arab States (UNESCO, 1986:27).

In the field of biotechnology and in co-operation with the International Cell Research Organisation and leading national institutes, 12 training courses were organised. In co-operation with UNIDO and other UN agencies, UNESCO organised the VIIth International Symposium on Biotechnology, the International Symposium of Genetic Manipulation in Crops, and the first workshop for establishing International Centres on Genetic Engineering and Biotechnology (UNESCO, 1986:28).

In spite of UNESCO's involvement in biotechnology-related activities, it was at the 1989 UNESCO General Conference that an international panel of experts recommended to Federico Mayo, then Director-General of UNESCO, the creation of the Biotechnology Action Council (BAC). The panel argued "the application of biotechnology could have far-reaching consequences and favourable impact in the developing countries, many of which suffer from large and rapidly increasing populations, chronic food shortages and malnutrition, poor health, and profound environmental problems". In fact, in broader terms, a resolution was passed in the 1990-1995 Medium-Term Plan inviting the Director-General to base the biennial programming on three main programme themes: science and technology for development; environment and natural resources management; and science, technology and development. Under the first theme, the resolution authorised the Director-General to:

- Strengthen national and regional capacities for university science and technology education and training by improving and renewing university and post-university education and training in basic and engineering sciences;
- To promote basic scientific research and its applications and dissemination of scientific and technological knowledge and information, through the strengthening of national research potentials; and most importantly
- To strengthen national and regional capacities and international co-operation in key frontier areas of basic sciences and technology, with special reference to information technology (Intergovernmental Informatics programme) molecular biology and biotechnologies, and in energy (new and renewable resources of energy).

In this regard UNESCO became involved in the promotion of biotechnology worldwide in 1990 with the establishment of the Biotechnology Action Council (BAC). BAC was thus charged with promoting the development and strengthening of national and regional capabilities in biotechnology in the developing countries by providing the opportunities for education and training in plant biology and biotechnology, and aquatic biotechnology as well as the efficient and rapid exchange of information in the developing countries. Thus, drawing on the expertise of some eminent scientists, BAC was charged with the responsibility of "promoting the development and strengthening of national and regional capabilities in developing countries by providing opportunities for education and training, and the efficient and rapid exchange of information" (DaSilva, 1998:1).

4.2.4.1 Biotech and MIRCEN Centres and Training in Africa

To achieve the objectives above the organisation (UNESCO) established five regional biotechnology education and training centres worldwide in 1995 to catalyse and develop capacity building and professional proficiency in the plant and aquatic biotechnologies. These centres, known as UNESCO Biotechnology Education and Training Centre (BETCEN) or the BETCEN network, include centres in Mexico (Latin and South America), Hungary (Eastern Europe), Bethlehem University, Palestine (Middle East) and Beijing (Asia). The UNESCO/BAC BETCEN for Africa was established at the ARC-Roodeplaat Vegetable and Ornamental Plants Institute in South Africa in July 1995. The last site for these centres was chosen after the Institute successfully hosted a pioneering All Africa Biotechnology Conference in 1994. Roodeplaat has therefore become the hub of several regional and continental initiatives in scientific research and training.

To keep Africa abreast of developments, UNESCO launched the "Biotechnologies for Development in Africa" programme in 1996 as part of the Worldwide Microbiological Resource Centres, MIRCEN network.[4] The Department of Microbiology and Biotechnology at the University of the Orange Free State in South Africa has also been chosen as one of the centres in Africa. Together the two selected institutions in South Africa serve as the Southern Africa node, besides their continental purview. These institutions train young researchers from the African region and beyond in modern techniques in plant cell culture, genome

[4] The world-wide MIRCEN network programme embodies research and training programmes that are carried out within the framework of UNESCO's regular and extra-budgetary programme activities as a follow-up to earlier cornerstone activities. The global MIRCEN programme therefore *attempts to*:

i. provide a global infrastructure which would incorporate national, regional, inter-regional co-operating laboratories geared to the management, distribution and utilisation of the microbial gene pools;
ii. reinforce the conservation of micro-organisms, with emphasis on rhizobium gene pools, in developing countries, with an agrarian base;
iii. foster the development of new inexpensive technologies for native-specific regions;
iv. promote the economic and environmental applications of microbiology; and
v. serve as focal centres in the network for the training of manpower (www.unesco.org/science/life/life1/mircen.htm)

analysis and genetic transformation as applied to common staple foods such as maize, potatoes, cassava; popular vegetable crops and also yeast biotechnology.

A short UNESCO training course in Yeast Biotechnology was organised in Bloemfontein (South Africa) from 26 January to 8 February 1998 for 12 researchers from East and Southern Africa, and two short training courses in Plant Biotechnology and Biostatistics were organised in Pretoria at UNESCO/BETCEN with 20 young African researchers per course. Within the framework of the Participation Programme for 1998-99, study grants in the field of General Biotechnology and Biostatistics were made available to researchers from Burundi and Uganda to undertake research in the United Kingdom (UNESCO, 2000).

Besides these two institutions in the Republic of South Africa, UNESCO also has three other Biotech MIRCENs in Africa, known as Rhizobium MIRCENs, dealing with biological nitrogen-fixation (BNF). One of these centres is at the Department of Soil Science, University of Nairobi, Kenya serving as the Research and Training regional Centre for East Africa, and the other at the Laboratoire de Microbiologie ISRA-ORSTOM in Dakar, Senegal for Research and Training Regional Centre for Central and West Africa. Lastly, the Faculty of Agriculture at the Ain Shams University in Cairo, Egypt serves as Research and Training Centre for the Arab States. Table 4.2 below shows the centres and their main activities. A common feature of all the centres is research and training as well as Culture Collection Research. In addition to these institutions a UNESCO Chair in Biology and Biotechnology was established at the University of Ouagadougou in Burkina Faso in 1995 and another one at the University of the Western Cape in Bellville, South Africa.

TABLE 4.2: Biotech MIRCEN centres in Africa

Institutional Location	Main Activity
Biotechnology MIRCEN Faculty of Agriculture Ain Shams University P.O. Box 68 Hadayck–Shoubra 11241 Cairo, Egypt	• Research and Training Activities for Arab States • Culture Collection Research
Industrial Biotechnology MIRCEN Faculty of Science University of Orange Free State Bloemfontein 9300 South Africa	• Research and Training Activities for Southern and Sub-Saharan Africa • Culture Collection Research
Rhizobium MIRCEN Department of Soil Science University of Nairobi P.O. Box 30197 Nairobi, Kenya.	• Produces 1500-1800 kg of rhizobial innoculant per annum • Research and Training Regional Centre of East Africa
Rhizobium MIRCEN Laboratoire de Microbiologie ISRA-ORSTOM B.P 1386 Dakar, Senegal	• Research and Training Regional Centre for West and Central Africa • Field trials with rhizobial and mycorrhizal inocula

Source: Compiled by researcher from www.unesco.org

Furthermore, support was provided in 1999 for the reinforcement of activities in BNF technology conducted by UNESCO/MIRCEN in Kenya and Senegal for East and West Africa respectively. An international Scientific Symposium was organised from 24 to 26 March 1999 by UNESCO/BETCEN in South Africa and UNESCO/MIRCEN in Kenya and Senegal on the theme Modern Areas of Plant/Microbial Biotechnology for researchers primarily from the African continent. The organisation also provided support to the Eighth Congress of the African Association of Nitrogen-Fixation, which was organised in Cape Town at the University of Cape Town from 23 to 27 November 1998. In addition, gifts of the *World Journal of Microbiology and Biotechnology* continue to be made available to institutes in Burkina Faso, Cameroon, Ethiopia, Ghana, Kenya, Malawi, Mauritius, Senegal, South Africa, Swaziland, Uganda, Zambia and Zimbabwe, while gifts of technical books totalling US$5 000 were made available to each of the UNESCO/MIRCEN libraries in Kenya and Senegal during the 1998-1999 biennium (UNESCO, 2000).

Since 1995 short- and medium-term training courses in Plant Biotechnology (Basic Tissue Culture and Advanced Tissue Culture) have been organised for African scientists lasting one to two weeks per course. The short-term courses focus on plant tissue culture and plant molecular markers, which includes the basic theory of plant tissue culture, basic laboratory protocols as well as practical sessions. Techniques included micropropagation, meristem cultures and long-term storage as well as rooting and hardening off. Crops included potato, sweet potato, strawberry, indigenous bulbs and cassava. According to Brink (1998:14), the Basic Tissue Culture courses were very popular and an average of 35 applications was received for every course. Brink also notes that the techniques were applicable for African scientists and that a majority of those who participated in the BTC also applied to attend the Advanced Tissue Culture courses.

The ATC course, which covered two weeks, included the basic techniques with additional information and theory. The course practicals included Anther Culture, Protoplast Culture/fusion (1996), Somatic embryogenesis, Cell suspensions, Transformation, and the Management of a Commercial Laboratory. The crops included potato, sweet potato, tobacco, indigenous bulbs, grapes, tropical crops, cassava and barley. An average of 40 applications was received for each course (Brink, 1998:15). Between November 1995 and December 1997 14 courses were presented by BETCEN in which a total of 107 scientists from 21 African countries participated in the BTC, while 12 countries participated in the ATC courses.

Besides the short-term courses, BETCEN also provided medium-term training between 1995-1997 in the form of fellowships for a study period of two to three months in the laboratories of ARC-Roodeplaat. In all, a total of 5 BETCEN fellowships were awarded to scientists from 5 African countries. Within the same period, UNESCO/BAC also awarded 3 fellowships to scientists to conduct research at the BETCEN (Brink, 1998:12).

Apart from the regional programmes, between September 1991 and April 1997, BAC awarded 310 short-term fellowships to scientists chosen from a pool of 2000 applicants, 47 from Africa, 83 from Asia, 30 from Arab States, 77 from Europe, and 73 from Latin America and the Caribbean. This is part of the attempt to facilitate and promote international scientific co-operation, since these visits are critical in establishing valuable contacts with eminent scientists and research groups, possibly leading to follow-up visits of longer duration. The awardees represented 80 countries and they went to laboratories in 40 different countries.

4.2.5 UNESCO ANSTI Programme

Following the 1979 Vienna Conference on Science and Technology, UNESCO helped in the establishment of the African Network of Scientific and Technological Institutions (ANSTI) on 6 January 1980, with funding from the United Nations Development Programme (UNDP) and the German Government GTZ (on this date the first co-ordinator of ANSTI assumed office). The idea of the network was conceived in response to the resolutions from the Conference of African Ministers of Science and Technology (CASTAFRICA I), which was held in Dakar, Senegal, in January 1974. At the CASTAFRICA I the Ministers and representatives implored UNESCO to help African universities and research organisations engaged in training and research in science and technology to establish such linkages among themselves to enable them to pool their human and material resources. Thereby they could contribute more effectively to the application of science and technology to development in Africa (Massaquoi, 1999). This will promote regional co-operation for enhancing the building of a critical mass of scientists and engineers through the Regional Centres of Excellence and regional institutional networks. The former involves the pooling of financial resources in order to establish regional institutions for training in highly specialised fields, while the latter involves the pooling of physical and human resources available in existing institutions for the purpose of training (Massaquoi, 1999).

The main objectives of the ANSTI programme are to establish and develop active collaboration among African engineering, scientific and technological institutions in order to promote postgraduate training as well as research and development in areas which are of relevance to the development of the continent. Therefore, through ANSTI human resource capacity-building projects, a number of postgraduate fellowships, visiting staff fellowships as well as short-term international fellowships have been awarded to a number of people. Also under this programme a number of seminars and workshops have been organised to promote scientific research and co-operation. The programme also has a textbook publishing scheme and publishes the *African Journal of Science and Technology*. Table 4.3 below shows the output of the ANSTI programme from 1980-2000.

The network consists of nine engineering and four basic sciences sub-networks Institutions in 30 sub-Saharan African countries participating in ANSTI.

TABLE 4.3: Output of ANSTI programme between 1980-2000

DESCRIPTION	Quantity (Nos)
Training and Capacity Building	
• Postgraduate fellowships	248
• Visiting staff fellowships	57
• Short-term international fellowships	8
• Travel fellowships	5
• Fellowships for technician training courses	6
• Sponsorship for the training courses	16
Seminars and Workshops	
• Sub-network (scientific seminars)	72
• Training workshop on maintenance	7
• Other training workshops	4
• Deans and directors conferences	5
Research Promotion	
• Grants for research	15
Publications	
• *African Journal of Science and Technology* (Series A, B and C)	32
• Directory of ANSTI Institutions	2
• ANSTI Newsletters	25
• ANSTI Sub-network Newsletters	43
• Engineering textbooks	6
• Science Textbooks	4

Source: JN Massaquoi, 1999

4.2.6 UNESCO's Expenditure on Science and Technology

In general, there are two main types of funding sources for the operations of the UN specialised agencies – regular (or assessed) funds and voluntary funds. The United Nations Development Programme (UNDP) is the major source of the voluntary finance, which, of course, cuts across the whole UN system. In addition the different organisations, which have their own regular and autonomous programmes and budgets, also have their extra-budgetary programmes financed from the same central voluntary fund (Desai, 1997:35). Meanwhile, following the United Nations Conference on Science and Technology for Development (UNCSTD) held in Vienna, Austria in 1979, developing countries in general were called upon by the World Plan of Action of the UN Advisory Committee on Science and Technology for Development to invest at least 1% of GNP on S&T research and development. Then at UNESCO's Symposium on Science and Technology in Africa held at Nairobi, Kenya in 1994 the DG of UNESCO, Federico Mayor, this time called on African governments to spend at least 0.4% of their GNP on S&T. Mayor also called on African governments to request the UNDP to spend at least 3% of its development financial assistance on S&T in Africa.

During a UN special meeting on science and technology in Africa at New York in 1999 Federico Mayor reiterated his call. In accordance with meetings of joint UNESCO/OAU Commission, the Priority African Department stressed the significance of developing S&T in Africa. For instance, the 35th session of the OAU Summit of Heads of State and Government (Algiers, 12-14 July 1999) adopted a resolution recommending that the developing countries gradually increase the proportion of their national annual GNP spent on scientific and technological research to at least 0.4%. At the same time the Summit recommended that 3% of the resources from the United Nations Development Programme (UNDP) be set aside for developing S&T. Therefore it is important for us to look at the expenditure pattern of UNESCO on S&T development and co-operation in general, but most particularly in Africa.

There has been a rapid expansion of UNESCO's activities as well as its budget over the years. According to Desai (1997:91), as of 1997 UNESCO was spending about US$54.8 million, of which amount 24.8 percent of the total was spent on science and technology, but it was difficult to invest this directly for productive purposes. The top priorities of the organisation related to cultural and educational activities and very little was allocated to scientific research, science policy and the development issues. Allocation to the science sector was, however, greatly enhanced from 10.9 percent in 1977-78 to 28.2 percent during 1981-83. During the year 1994-95, though environmental programmes were integrated with science programmes, there was a reduction in the proportionate allocation for science programmes (Desai, 1997:91).

Besides providing financial support to developing countries, UNESCO also warned against a tendency that was prevalent among certain international financing organisations to regard research and development or scientific technological services as marginal expenditures. UNESCO argued that by emphasising financial support on short-term basis as applied to scientific and technological projects in, for example, industry or agriculture, existing research capacities are strengthened to the detriment of new ones in fields hitherto neglected (Behrman, 1979:53).

During the 1998/99 biennium the countries of Sub-Saharan Africa received 25 percent of the overall Participation Programme budget, representing a total of US $6,626,610, allocated to national, sub-regional, regional and interregional projects. This assistance often covers areas such as the provision of specialists and consultant services, further training and study fellowships, publications, subscriptions to periodicals and documentation, equipment supplies, the organisation of conferences and meetings, seminars and training courses. Although limited to 15 projects in a biennium, the financial assistance also has an upper limit of $26,000 towards the conduct of a national activity or project and $35,000 for a sub-regional, regional or interregional activity or project. For example, during the biennium through extra-budgetary sources, UNESCO was able to finance 303 projects in Africa with 70 regional projects and 233 national projects in 45 countries to a total of US$115.9 million (UNESCO, 2000). It is unclear, however, how much of this amount went into financing science and technology or related activities, especially at the regional level. Perhaps the only data that may shed some light on the pattern of UNESCO spending, and on what activities, in the last five years are the data on Southern Africa in Table 4.4 below.

Table 4.4 shows the general budgetary allocation on scientific and technological activities supported by UNESCO and some related UN agencies for three biennials: 1996/97, 1998/99 and 2000/2001 for Southern Africa. As the table indicates, biotechnology activities (training of manpower, equipment, and fellowship) have been allocated the biggest share, with over hundred thousand US dollars in each of the three biennials represented. This may not represent the general pattern throughout UNESCO operations in the region, as attempts to obtain such statistics have not been successful.

TABLE 4.4: UNESCO biannual budgetary allocations for Southern Africa

BIENNIUM	**1996/97**	**1998/1999**	**2000/2001**
Biotechnology (training, equipment, fellowship)	111,500	110,000	106,600
Training in other scientific fields and networking	26,500	50,000	52,700
Renewable Energy	59,700	120,000	18,300
UNESCO Chairs	38,000	60,000	28,200
Environmental Science	10,000	52,600	35,700
Co-operation for Development		30,000	20,000
TOTAL – REGULAR PROGRAMME	***245,700***	***422,600***	***261,500***
Special Programme for South Africa	84,000		
Extra-budgetary: UNDP		199,500	
Extra-budgetary: Other Sources			300,000
GRAND TOTAL	**329,700**	**622,100**	**587,500**

Sources: UNESCO, South Africa

4.2.7 Evaluation

In our discussion on theory in Chapter Two, we noted that four elements are important for the sustainability of knowledge-based development: infrastructure, skills, experience and knowledge. From our discussions of the above it is clear that, although some institutional structures have been utilised to promote scientific and technological capability building in Africa, the UNESCO programmes have not been able to establish even one scientific or technological institution. Therefore UNESCO, like the colonial scientific organisation of the Scientific and Technical Commission for Africa, has to depend on the magnanimity of national research councils for a use of their infrastructure to promote its programmes. Africa's biotechnology programme cannot take off without scientific development in terms of infrastructure. But there is lack of support for the creation, directly by UNESCO, of new scientific infrastructure for biotechnology development. However, one exception to their credit is the provision of equipment for these institutes as part of the general scientific and technological capability building. But this is in limited supply.

We must also acknowledge the difficulties involved in estimating the level of funds allocated for activities clearly related to science and technology in the programmes of different UN organs or specialised agencies, as well as the technical aid distributed by them. Even at the regional level, where operations could have been separated, it is difficult to make a clear distinction, since most S&T activities are contained within a large programme description or otherwise the S&T components may be inseparable from the total operational activity (see Desai, 1997). These declining trends in funding could not have come at a worse time for Africa. For example, the UNDP share of Industry declined from 13.4 percent to 9 percent in 1992. Science and Technology has been accorded the lowest priority (4.3 percent) and allocations to this area have actually declined from 6.4 percent in 1972 to 3.8 percent in 1992 (Desai, 1997:38). Although there is no regional breakdown of the UNDP expenditure, there is no doubt that it affects Africa. For instance, in 1989 UNDP decided to abandon its voluntary fund support to the UNESCO ANSTI programme. But for the decision by the German government to continue its support, ANSTI would have been a moribund programme.[5]

Overall, although UNESCO is the only UN specialised agency with the mandate to promote science enshrined in its constitution, its expenditure on S&T has not been up to the level of

[5] Interview with Prof. J Massaquoi, Senior Science and Technology Policy Advisor, UNESCO Regional Office, Nairobi Kenya, May 2001.

funds committed by some of the other UN agencies. This is illustrated in Table 4.5 below, where the WMO and the WHO as well as the ILO expenditure on S&T is seen to be much higher than that of UNESCO, especially since the mid-1980s. However, Desai (1997) notes that, due to the fact that much of the UNDP funds come from voluntary sources, it has introduced stricter competition in order to create room for progress. Therefore UNESCO's reliance on extra-budgetary resources (which currently stands at 46%) to fund its programmes may not guarantee the sustainability of such programmes, including ANSTI.

TABLE 4.5: Expenditure on S&T by selected UN Agencies (US$ million)

Organisation	1978-79	Percent	1980-81	Percent	1984-85	Percent
UNO	52.8	22.5	58.5	20.7	20.8	5.8
UNIDO	9.7	4.1	5.6	2	18.7	5.2
ILO	3.9	1.7	4.1	1.4	65.3	18.2
FAO	6.5	2.8	12.3	4.3	30.6	8.5
UNESCO	54.8	23.3	78.8	27.8	43.6	12.2
WHO	0.6	0.3	0.9	0.3	127.2	35.5
WMO	56.4	24	58.2	20.6	6.5	1.8
WIPO	18.4	7.8	24.3	8.6	1.4	0.4
IAEA	13.5	13.5	40.4	14.3	43.2	12.1
	$ 234.9	**100**	**$283.0**	**100**	**$358.1**	**100**

Sources: Science, Technology and International Co-operation (Desai, 1997:45).

Besides, the regional commitments of the Organisations are still better than those of UNESCO and therefore UNESCO is considered as less "regionalised" than the WHO, ILO and FAO. This is because UNESCO is spending a disproportionate 70 percent of its budget at the headquarters in Paris, while neglecting the regional offices, while programmes are also given a low priority (Desai, 1997:89). A case in point is the creation of the Priority Africa Department in Paris – this has resulted in a reduction in the amount of resources available to the field offices and programmes in Africa. To this extent regional policy issues are still formulated in Paris, with very little input from the field.

The only long-term programme run by UNESCO in S&T is the ANSTI programme, but ANSTI has had no research infrastructure in the 20 years of its establishment. Even the programme makes no adequate provision for the supply of scientific equipment to assist institutions to upgrade their research infrastructure. In order to remain a viable programme, ANSTI has to rely on national institutions. There has also not yet been any impact assessment of the programme. Similarly, UNESCO's biotechnology programme relies on the national research infrastructure for training and workshops, although here some money is devoted to the supply of equipment to the training centres. Yet some of the scientists who come for these short courses find that, on their return home, there is no such scientific equipment and material to work with. This, in part, leads to the exodus of scientists and engineers to more developed countries, mostly outside Africa. Nevertheless, both ANSTI and the biotechnology programmes have helped in developing a limited number of scientific and technological skills and equipment (see Tables 4.3 and 4.4 above).

Generally UNESCO's activities, particularly through policy advice, have helped in building educational infrastructure at the national level. UNESCO has also provided great impetus to some useful activities like standardisation. In fact, if its policy advocacy was to match national support with practical support on a long-term basis for the development of S&T in the developing countries and Africa in particular, then it could have no competitor. For example, in the current debate on debt relief for the least developed countries UNESCO argues through the Heavily Indebted Poor Countries Initiative (HIPC) that:

> The current approach to debt relief for HIPCs takes into account only a few elements which contribute to the development of science and technology, but is without an overall strategic view. For example, a broad base of people able to read and write, as well as a stable macro-environment, where private innovation and investment is encouraged, are fundamental in the long term to technological development. HIPC Initiative, however, does not take a systems approach to science and technology. It does not examine the quality, relevance, and adequacy of high-level training programmes, applied scientific and technological research and knowledge linkages with the rest of the world. At most, a few of the strategies mention the need for agricultural research (UNESCO, 2000:11).

The Organisation's policy proposal further argues that S&T is as critical for poverty reduction as basic health and education, governance and macro-economic stability because:

- Poor countries are in critical need of scientific knowledge and technological know-how to generate local solutions to their pressing problems in the areas of public health, water supply and purification, sanitation, food supply and nutrition, energy, communication, etc.;

- S&T is the necessary input for economic development, which will raise the standards of living for all and make countries less poor. Development cannot be sequential, starting with basic education and health, and later concentrating on higher education, but must be simultaneous;

- S&T can help the traditional sectors to identify appropriate technologies to improve productivity and help in the transition from the traditional to the modern sector;
- S&T helps poor countries to come out of isolation and marginalisation and empowers them with knowledge and tools to actively participate in and benefit from the technologically sophisticated global economy;
- Technology can also help countries to leapfrog directly to more sophisticated technology, as in the case of cellular telephones and, in the near future, the Internet, using the air waves rather than hard wiring (UNESCO, 2000:14).

In the past UNESCO paid very little attention to the staff, resource allocations or structural mechanisms with which to confront socio-economic problems related to science and technology (Desai, 1997) in areas where regional and sub-regional programmes will be very useful in overcoming the individual nations' weaknesses. More of the available resources, time and effort have been spent on the organisation's conferences, meetings and seminars with fewer resources subsequently available for actual research and development activities in Africa. UNESCO should start implementation of these ideas itself and also try to influence the policy direction of the World Bank and the IMF, and other multilateral and bilateral donor institutions that support the HIPC Initiative in promoting S&T for development in Africa.

It is also worth noting that in the area of funding UNESCO was able to launch the Science Fund for Africa with seed money of US $1 million. Meanwhile, its assistance to African countries is weighted heavily in favour of national capacity building, rather than strong regional and sub-regional programmes. If UNESCO adopts these latter programmes, it will be able support the development of the appropriate scientific infrastructure, and it will not be necessary for it to support every country in developing individual programmes.

Conclusion

UNESCO's contributions to the development of S&T in Africa have evolved since the 1960s, when African countries started gaining independence. Its support for the development of scientific and technological infrastructure has been modest, limited to supplying laboratory equipment and scientific journals. However, its policy advocacy has led to the institutionalisation of modern science and S&T infrastructure in most African countries. Through its fellowship programmes, it has been able to offer training opportunities to develop a few scientists as human resources critical to Africa's development, especially through the ANSTI Programme that it administers.

However, its direct support for regional and sub-regional S&T programmes for co-operation and development is limited and very recent. Besides this, it has to rely on national governments who already have the necessary educational and research infrastructure, to enable it to bring in and develop its programmes, e.g. the biotechnology programme. Nonetheless, it regards the role of science and technology as fundamental in the knowledge for development discourse and co-operation highly.

4.3 THE ROLE OF THE WORLD BANK IN THE PROMOTION OF S&T FOR INTERNATIONAL DEVELOPMENT

> *"As the World Bank seeks to become a 'knowledge bank' it must examine the role of scientific and technological knowledge in development, and how S&T are to be embodied in the Bank's program."* John Daly, March 2000

4.3.1 Introduction

The International Bank for Reconstruction and Development (IBRD), generally known as the World Bank, or simply the Bank, was established in 1944 and began its operations in 1946. Together the World Bank and the International Monetary Fund (IMF) are referred to as the Bretton Woods twins after the deliberations that were held at Bretton Woods in New Hampshire in the United States of America (USA). The World Bank Group includes the International Finance Corporation (IFC) set up in 1956. International Development Association (IDA), the 'soft' arm of the World Bank (providing finance on easy terms as opposed to hard loans at full market rate) was established in 1960. The World Bank has become the largest source of development finance for Third World countries (Arnold, 1994:25).

In recent times, and particularly since the world debt crisis in the 1980s, if any international institutions have attracted a great deal of attention, they are the International Monetary Fund (IMF) and the International Bank for Reconstruction and Development (IBRD). This attention has been directed at them because of their relationship with the Third World – in particular their failure to help developing countries overcome their economic weaknesses; this latter fact often overshadows whatever good policies they may have initiated in the Third World. Some analysts praise the World Bank; some condemn it. But, as Payer (1982) puts it, no one can escape its influence. This section is an attempt to look at this institution (World Bank), its relationships with developing countries and the impact its policies have, particularly with regard to the development of science and technology in Africa. Given that the World Bank Group is the largest lender of long-term financial resources to developing countries for their development programmes, neglect of S&T in their operations will be a recipe for disaster.

4.3.2 The Genesis of the World Bank

The beginnings of the World Bank can be traced back to the efforts to build a sound international economic order after the Second World War. However, the origins of the IMF can be traced to the Great Depression of the 1930s. The Depression had such a devastating effect that banks by the thousand failed to perform, the price of agricultural products fell below the cost of production, land values plummeted, factories stood still and tens of millions of workers lost their jobs. Moreover, this Depression spread into international finance and monetary exchange as the volume of monetary transactions among countries contracted (Tayeb, 1992:76). Various governments adapted their policies, which were themselves unsound, and attempted to apply them to effect recovery in the international economy. This led to several international conferences being called in the 1930s to address world fiscal and monetary problems. These failed, well beyond the outbreak of the Second World War. Negotiations continued during the War, with the United States and Britain playing roles of major importance.

However, the final negotiations for the establishment of the International Bank for Reconstruction and Development (World Bank) and its sister institution (the International Monetary Fund) took place among the delegates of forty-four countries who gathered at Bretton Woods, New Hampshire in July 1944. Hence the two institutions are often referred to as the Bretton Woods "Twins" or Institutions. The IMF came into being on 27 December 1945 and began operating in May 1946 in Washington DC, with 39 members (Tayeb, 1996:77), while the World Bank began its operations in June 1946 with 38 members (Williams, 1994:103). The membership of the World Bank was made conditional on membership in the IMF. According to Payer (1982), one of the drafters later remarked, "basically we wanted to force countries to agree to standards in the monetary field as a condition to get the benefits of the Bank". This has since changed. The membership of the Bank now stands at 183 (September 2001).

4.3.3 Aims and Financial Resources

The World Bank is the foremost international development agency and, at the same time, the leading international agency currently financing economic development. The World Bank Group consists of four agencies created over the years.

- The International Bank for Reconstruction and Development, which makes loans linked to commercial rates of interest largely to middle-income developing countries.
- The International Finance Corporation (IFC), established in 1956 to assist economic development in poor countries through investing in private projects (equity investments), supports the growth of capital markets and encourages the flow of domestic and foreign direct capital. It also provides loans with government guarantees.
- The International Development Association (IDA), created in 1960 as the soft loan affiliate of the IBRD, provides loans to the poorest developing countries on very favourable terms, generally over a period of ten to fifty years (the repayment period has now been changed to a maximum of 40 years).
- The last and most recent of these agencies, the Multilateral Investment Guarantee Agency (MIGA), was established in 1988.[6] It aims at encouraging the flow of foreign direct investment to developing countries through the lessening of non-commercial barriers and insurance guarantees against political risks (Williams, 1994:101; Payer, 1982:27, 33; World Bank 1991).

All the above four institutions follow virtually the same policy guidelines and similar, if not identical, procedures in appraising and supervising project work, especially the IBRD and the IDA, whose main difference is in the holding of separate accounts within the same institution, with the IDA sharing the staff of the IBRD.

The World Bank makes loans on relatively conventional terms. Its loans have a grace period of 5 years and are repayable over a period of 15-20 years. Its shareholders are member countries that hold voting rights proportional to their shareholdings. They own the Bank. The Bank's capital structure is made up of authorised capital, callable capital and its own

[6] The International Centre for Settlements of Investment Disputes, established in 1966, is now part of the Bank Group.

borrowings. Each member pays one-tenth of their share capital creating a common liquidity pool of pay-in capital, which finances the operations of the Bank. The remaining 90 percent of the share capital is held by governments as callable capital and are subject to call if and when required to meet the Bank's obligations. However, the bulk of the Bank's loanable funds are borrowed on the capital markets and central banks. It is also a major factor in world capital markets and is considered the largest non-resident borrower in almost all countries where its issues are held (Payer, 1982).

The Bank only borrows from countries that have balance of payments surpluses, since this is easier and less costly in nominal terms. The currency borrowing does not necessarily have to coincide with the nationality of investors. For instance, members of the Organisation of Petroleum Exporting Countries (OPEC) held approximately US$3.6 billion at the end of 1977, which represented about 17 percent of the total outstanding borrowings (Payer, 1982:30). The borrowing strength of the World Bank led Marc Williams (1994:105) to conclude that "unique among international organisations, the IBRD finances most of its operations from its own borrowings in the world capital markets".

Furthermore, the World Bank lends money at interest rates which are more favourable for borrowers than those they can obtain from the market, despite the fact that the Bank itself raises most of its funds on the world capital market. The Bank also charges all its borrowers the same interest rate, which may be adjusted at quarterly intervals. Thus the interest rates are fixed over a relatively long period. Often the interest rate is determined by calculating the average cost of borrowing in a given period and adding a spread of point five (0.5) percent. This is made possible because the shareholders of the Bank (its member governments) do not receive any interest or dividends on their contributions. It should be noted that, since the late 1970s, the World Bank no longer gives loans to developed countries. Only developing countries can borrow from the Bank. This means that the Bank's members from the developed counties can benefit only from procurement opportunities derived from the World Bank-financed projects.

4.3.4 The Traditional Roles

As said earlier, the World Bank was established as a development institution. Its focus was the provision of long-term finance for the development of productive resources. Its early preoccupation was the reconstruction of Europe after the Second World War. It has "an orientation towards the supply side of the economy, the real sector and project lending" (Bird 1994:487). Bird notes that it has never been possible to draw sharp distinctions between the balance of payments and economic development, although legitimately the distinction exists. The different roles played by these institutions has somehow given the World Bank a better image in developing countries than the IMF, since it is development oriented and project visible in the eyes of the ordinary layman. For instance, the funding of infrastructure development in the developing countries has been fundamental in the history of the Bank. The Bank has financed transportation network projects ranging from roads, railroads and ports (for the promotion of exports and imports). Most of the Bank's aviation loans have over the years helped to finance the modernisation of airports, the major purpose of which is to speed up the transit of passengers through airports. All these projects have helped in the integration of developing countries into the world economy, as well as benefiting their own internal development. For example, most rural development projects contained a component for the improvement of roads, and the highway loans were often announced as concomitant with, or preceding, rural development, before the debt crisis in the early 1980s.

Furthermore, the financing of electric power projects was one of the first types of lending from the Bank to developing countries, and for many years remained the largest sector. For instance, at the end of the 1980 fiscal year this sector represented cumulatively the second largest sector after agriculture and rural development, with over US$14 billion, or 21 percent of the total funds lent by the Bank for all purposes throughout its history (Payer, 1982:100). The World Bank Group Report of 1963 noted that an early power loan to South Africa purported to relieve acute power shortages on the Rand, which contained many important mining and industrial centres. Within the same period, another was given to Swaziland to meet the power requirements of the Swaziland Iron Development Company (Payer, 1982:101). Similar project funds were made available to the Judith Tendler Electric Project in Brazil and the Guri Dam in Venezuela, among others.

However, critics of the Bank argue that power projects had been found particularly suitable for Bank lending because they are heavily capital intensive, requiring imported equipment produced mostly by the developed countries. Nevertheless, they contributed greatly to the development needs of these countries at that point in history, even if the major beneficiaries were Western multinational corporations.

The recent upsurges of internal conflicts in developing countries have led the Bank to become involved in what it calls post-conflict reconstruction work, mostly in the rebuilding of infrastructure. For instance, in the 1997 fiscal year lending involved funds for the clearing of land mines in Bosnia and Herzegovina and Croatia, demobilisation and reintegration of ex-combatants in Bosnia, and the reintegration of displaced people in Bosnia and Rwanda (World Bank, 1997).

The World Bank is still the largest source of development aid and it is clearly of importance to developing countries. For instance, in 1985 the Bank's provision of technical assistance was valued at $1,148.4 million for 203 operations, while the figures for 1984 came to $1,093.2 million, also representing 203 operations. In addition, the Bank spends more than $100 million a year on free-standing technical assistance loans (Arnold, 1989:150-151), while in 1991 the Bank assistance to the poorest countries with per capita GNP of $580 or less amounted to $9,335 million (World Bank, 1997).

Despite these functional projects financed by the World Bank over the years in developing countries, the relationship between the two sides cannot be described as cordial. That is, a shift to policy-based lending in the 1980s, with increased collaboration with the IMF, by the Bank in the wake of the world debt crisis and global recession drew greater attention to both institutions and, more importantly, the *conditionalities* associated with structural adjustment loans in the Third World.

Arnold (1989) has observed that one of the Bank's most acclaimed documents was its *1981 Accelerated Development in Sub-Saharan Africa* (An Agenda for Action) but "this was badly received in Africa. Its analysis of the continent's problems once accepted, the Bank descended upon the continent like a *deus ex machina,* analysed its ills and prescribed solutions with far too little reference to what Africans wanted or were trying to achieve". The argument is that most of the solutions, which are offered, are far too akin to the market policies favoured by the West. As far as Arnold is concerned, "if the Bank acts like a nanny instructing the developing world, the IMF is the policeman".

The executive director of the Bank is bound by government instructions and is not, as are international civil servants, loyal to the Bank and to the international community. The president of the Bank has enormous discretionary powers and is at the apex of a pyramidal structure. The president is freer of political constraints than any other UN agency head. The costs of running the Bank itself (buildings, staffing, country investigations, research and the like) are met directly from operating profits, and the president is an independent actor in meeting his administrative budget. At this juncture we shall shift our attention to the Bank's role in financing science and technology development in general, and in Africa in particular.

4.3.5 The Bank and the Promotion of S&T

We have noted in the previous chapters that interest in S&T is not lacking in the UN agencies – to the extent that some agencies have "Science" in their name (e.g. UNESCO), while others do not, though science is reflected to some extent in their development activities. In fact, realising that science and technology cannot be divorced from the discourse of development, the early years of the Robert McNamara presidency saw an unprecedented intellectual energy expended in the World Bank, with it taking a keen interest in science and technology in the 1970s. This interest led to the creation of a Unit of Science and Technology in the Bank. McNamara appointed Charles Weiss, who had a background as a biochemist, to be his adviser and head of the Unit. The aim of the Science and Technology Unit was to scout for new developments in S&T useful to the Bank and to bring them to the attention of project staff (Walsch, 1984).

The Unit, for instance, advocated the establishment of a remote sensing unit in the Agricultural and Rural Development Department of the Bank. This recommendation led to a significant use of this technology in the Bank's operations. The S&T Unit further played a role in stimulating the Bank's interest in low-cost technology (Walsch, 1984:149), badly needed in developing countries.

It is in the light of the above involvement in technological projects in development that Nicolas Jéquier and Charles Weiss (1984:1) describe the World Bank as a *technological institution* because it is an organisation that "directly or indirectly finances or carries out research, transfers technology, promotes better choices and uses of technology, encourages innovation, and contributes to the building up of technological capability". Jéquier and Weiss note that all this is due simply to the Bank's role as financier of projects that involve technology in one way or another. For instance, machinery purchased from industrial suppliers often requires people to be trained in new skills to be able to operate productive units efficiently. Likewise, new crops and new ways of operating have to be diffused to farmers. Some of the necessary technologies have to be transferred from abroad, while others have to be generated locally, and project execution leads to the building of a local technological capability in the country concerned. According to them, what really makes the Bank a technological institution is its "active role in the choice of technology appropriate to each particular situation and in the mobilisation of local technological capacity for the accomplishment of socio-economic objectives and human development" (Jéquier & Weiss, 1984:2).

In a document prepared as part of the documentation for the Bank's contribution to the 1979 UN Conference on Science and Technology in Vienna and later published, the Bank has been described as an "agent of technological development in the developing countries" (Shapiro, 1982:1). This document was the first comprehensive work written on the operations of the Bank in the areas of science and technology. It noted four basic technological objectives in the Bank's operations:

1. *To ensure that the most appropriate technologies are used in the projects it finances.* Those technologies must be appropriate to the objectives of the project; to the broader development objectives and aspirations of the particular country; to the local social, cultural, economic, and environmental situations; to available local raw and semi-finished materials; to the local and grass-roots capacity to plan, operate and manage; and if this is a principal project objective, to creating opportunities for productive employment and to alleviating poverty. The appropriateness of technology to specific factor endowments and local conditions will ensure efficiency in the allocation of resources;

2. *To promote the development of technological capacity in developing countries.* This is defined as the capacity to plan, assess, choose, acquire, adapt, implement, manage, operate and generate technology. It requires a pool of trained individuals. It includes a capacity for training, engineering, pre-investment studies, sector planning and scientific and technological research. It implies the integration of research efforts with production and policy-making and the focusing of that research on the problems of poverty and the need for productive employment. The development of this capacity will foster the operational efficiency of production units;

3. *To promote the generation, diffusion and application of innovative technologies* needed to solve development problems, especially those of the poor;

4. *To promote the adoption by developing countries of national policies* that can foster local technological capacity and lead to the use of technologies suited to local conditions, especially to the needs of the poor.

In view of these objectives the Bank has increasingly been involved in a number of initiatives in areas of operation covering varied fields in science and technology in education, agriculture, health, rural and urban development, water and waste disposal, telecommunications, energy and population among others, all of which deal directly or indirectly with the application of S&T to socio-economic development. In light of this, we have to make choices and therefore the educational sector, because of its important role in building many human resources bases if good infrastructure is provided, is given priority. We have already mentioned the agricultural, health and the energy project sectors, in which the Bank has partially financed projects in Africa, in the previous chapter. According to Thulstrup (1993), most of the support for agriculture, industry, infrastructure and education was given to research within science-based fields. Does that relate to Africa?

4.3.6 The World Bank: Education, Science and Technology

The building of the required human capacity and skills in S&T begins with education. Most of the progress made in modern S&T is a result of the formal education which both inventors and innovators have acquired. Hence the educational sector (particularly higher education at the tertiary level and beyond) has been chosen because, without investment in institutions of higher learning as well as research institutes, the manpower needs of Africa to develop Africa's resources cannot be fulfilled. In fact, from 1944 until 1962 investment in education was not part of the original mandate of the Bank and it never financed any educational project. The World Bank's involvement in education project financing worldwide was initiated in 1962 and it began lending in 1963. This coincided with the time when many colonies in Africa, Asia and the Caribbean were becoming independent and were rapidly developing bureaucracies to manage public investments designed to stimulate economic growth and development. For example, on the eve of the Second World War, only Liberia, Ethiopia and Egypt were independent countries in Africa (excluding South Africa). In 1959 this figure rose to 9, including Sudan, Morocco, Tunisia, Libya, Ghana and Guinea. They were followed in 1960 by another 17 countries: Nigeria, the Congo, French Togoland, French Cameroon, Somalia, Malagasy, Dahomey, Gabon, Niger, Republic of Congo, Cote d'Ivoire, Chad, Central African Republic, Mali, Senegal, Mauritania and Upper Volta. In 1961 2 countries, Sierra Leone and the federation of Tanganyika, Uganda and Nyasaland, also achieved independence. With Burundi, Rwanda, Algeria and Uganda gaining independence in 1962 and Kenya in 1963, this brought the total number of African countries that would require financial assistance from the World Bank to 33.

Throughout most of the developing countries in the 1960s there was a critical shortage of administrative, scientific and technical manpower. This situation was particularly acute in Africa, where higher education institutions had been established only recently or at the time of independence, while the most senior ranks of the public service and research institutes were staffed predominantly by expatriates (Eisemon & Holm-Nielsen, 1995). Hence the newly independent African countries lacked the trained personnel in the various areas of high priority for their future development. As we noted in Chapter Three of this study, higher education and particularly it's training of the science and technology as well as the engineering workforces became a national priority to all the countries. Such institutional and manpower capacity building in S&T could only be enhanced if the World Bank and other development finance institutions became interested and provided funding.

In this respect the World Bank's early education projects were focused on the country's manpower requirements, as the Bank argued, "The shortage of skilled manpower, aggravated by the withdrawal of the foreign population, is a major impediment to economic growth". Therefore the World Bank Group began lending for education in 1962. By the end of the 1970 fiscal year, the cumulative total of the Bank and IDA education lending amounted to over US$320 million. About half of this total was lent in 1969 and 1970, i.e. $81.8 million and $79.9 million respectively, as well as an average of $31.4 million between 1964 and 1968 (World Bank, 1970:13-14).

The Bank's first project with a higher education component supported secondary teacher training in Tunisia in 1963 (Jones, 1992:xv). The Tunisian government sought a loan to finance the construction of middle and secondary schools as well as new facilities for Ecole Normal de Professeurs Ajoints. In 1962 the World Bank noted that the Universite de Tunis, which was then recently built, would be the indirect beneficiary of the project because an increase in the number of secondary schools graduates would lead to the teaching of most university subjects (Eisemon & Holm-Nielsen, 1995:4).

The Bank's first university project was financed in Pakistan (1970), where the project addressed two key sectors which were identified by manpower planners as critical: shortage of agricultural professionals and industrial technicians. The Bank's funding in this instance was made available for construction of facilities, purchase of equipment and recruitment of expatriate personnel (Eisemon & Holm-Nielsen 1995:6). In the 1970 fiscal year the Bank Group specifically made three commitments to support higher education programmes related to the development of science and technology and which the Group considered as relevant to economic development. Thus an amount of $8 million IDA credit went to Pakistan for the West Pakistan University of Engineering and Technology at Lahore and the Government Engineering College at Karachi. In the same financial year a US$6.1 million IDA credit was committed to Kenya, which, apart from supporting agricultural education at the secondary level as well as at the primary and secondary teacher training, was to assist in the establishment of Kenya's first University Faculty of Agriculture. Another amount of US$5.3 million of World Bank loan was approved for Zambia for the expansion of the Faculties of Engineering and Education at the University of Zambia. It was then anticipated that the project would enable the University of Zambia (whose enrolment was expected to treble by 1973) to provide new lecture rooms, laboratories and other facilities for the two faculties. Through the project funds were to be made available for the construction and furnishing of hostels for 960 students and staff (World Bank, 1970:14).

4.3.6.1 World Bank's Supports for Specific S&T Projects in Africa

Besides the projects relating to Kenya's first Faculty of Agriculture and the University of Zambia mentioned above, the World Bank has provided some support for projects that are relevant to this study because the World Bank makes provisions for the development of scientific infrastructure and helps in training a cadre of scientists and engineers. One project is contracted in each of the following countries: Ethiopia, Algeria, Ghana, Mauritius (which had two), Kenya and Egypt. During the 1973 fiscal year Ethiopia acquired a Bank loan of US$10.0 million to support a project with a total cost of US$12.7 million to enable it to raise the level of science and technology training throughout the educational system. According to Muskin (1992), the project's objectives included:

- Improving and expanding the level of university science instruction;
- Improving secondary level science teaching;

- Expanding the supply of textbooks and other instructional aids;
- Increasing the supply of trained manpower for agricultural investment programmes;
- Improving rural self-learning mechanisms; and
- Improving educational planning.

However, Muskin notes that, of the six main components, only one was related directly to higher education science and technology instruction in that it entailed the renovation and expansion of the Science Centre of the Haile Selassi I University. The project funded various civil works, equipping laboratories and other educational facilities, and funded curriculum development and training of laboratory technicians.

Muskin's study indicates that the project completion reports (PCR) evaluation concentrates almost exclusively on the execution of the construction and procurement programmes, as well as the expansion of the university science centre's capacity. In general, the project execution assessment was considered to be very favourable; for example, the expansion of capacity far exceeded the anticipated levels, while services provided to industry, such as chemical analyses, also increased significantly. However, the extent and effectiveness of these expanded activities were not described. In a similar vein, no data were gathered on the impact of the expanded facilities and capacity on the quality of higher education science instruction. Muskin (1992) concludes that, of the four major "lessons learned" as stated in the completion report, three were more generic and applicable to all projects; while the fourth stated the need to refer equipment lists to independent review authorities.

In 1990, under the *Egypt: Engineering and Technical Education Project*, which was meant for the development of human resources, Egypt acquired about US$ 16 million (roughly half of the loan) that was dedicated to the Engineering Education Development Programme. Faculties were to be encouraged to upgrade their academic curricula, teaching staff and laboratory instruction programmes and to establish and maintain strong linkages with industry as well as to reorient their programmes towards more applied engineering. Faculty selection was to be based on a competitive proposal process involving open review and an assessment (with peer group involvement) and subsequent funding of acceptable institutional proposals (Crawford & Brezenoff, 2001).

Furthermore, the second set of projects pursues the same general goals as the other two, but with no explicitly performance-based funding procedures. These projects often contain support for research infrastructure, albeit without clearly redesigning mechanisms for allocating the support. They range from basic provision of laboratory or other science equipment and libraries, reform of curricula and teaching methodology, creation of new courses, staff and researcher development through overseas fellowships, and support for library resources and scientific information to more autonomous university management and development. Collaborations among universities (both local and foreign) and research institutes, and linkages with industry, are built into many of these projects, which reflect the necessity of knowledge sharing as a basis for knowledge creation (Crawford & Brezenoff, 2001).

In 1991 a US$65 million loan was approved by the Bank and matched by the government of Algeria to finance the pilot phase of an expansion of teaching and research programmes at three leading science and technology universities. A crucial aspect of the project was the decentralisation of higher education financial and operational management and planning by enacting a "transparent and rigorous" institutional peer review process. The innovation seeks to support several objectives, including:

- Assisting the government in upgrading undergraduate teaching and research at the three major universities of science and technology;
- Improving university management and administration;
- Improving curriculum relevance, teaching quality, and teacher qualifications in selected science and technology degree programmes; and
- Promoting closer research and training links between universities and local industry.

This project was to provide funds to three universities on the basis of submitted proposals. Investment proposals for improving teaching and research programmes will be assessed by a peer review process with criteria focusing on relevance to national and regional science and technology needs and the institution's demonstrated ability to perform and manage the project. Funds would be provided specifically for the teaching, research and administrative staff, for improved teaching and research facilities, for improved site and equipment maintenance capacities, and for upgraded library and computing facilities.

According to Muskin (1992), the Algerian government initiated this proposal mechanism to push science and technology universities to impose greater self-control in managing resources efficiently, to develop programmes that fit regional as well as national priorities and to pursue closer ties with industry. The mechanism of subjecting competitive bids to peer review is intended to ensure careful planning and implementation of projects. However, with only three participating universities, all of which the government is committed to supporting, it may be difficult to enforce strict standards in reviewing proposals. Without a robust field of competitors, there is little recourse in the event of unsatisfactory performance. Thus there is little pressure for programmes to conform to government objectives. If the pilot stage were to fail, the reason might lie in the limited field of competitors rather than in the model itself (Muskin, 1992).

The *Kenya: Universities Investment Project* has a small research fund (US$1.5 million), which is devoted to applied research. The funds for institutional development were equally divided (not competitive) into four US$10 million institutional grants, one for each of the four leading universities. On the other hand, the Mauritius *Higher Education and Technical Education Project* dedicated 80% of project resources to the improvement of science and engineering education, similar to some university projects. However, US$5 million was devoted to "rationalisation of polytechnic education". This included the development of new degree programmes and increasing their relevance by improving the balance between basic and applied work in the curriculum (Crawford & Brezenoff, 2001).

In fact, after pursuing structural adjustment programme for nearly two decades, the Ghanaian government's borrowing from the World Bank had never supported scientific research and development, except in 1995 when an amount of $13 million was lent to the Ghanaian government under the Private Sector Development Project (PSDP) (Crawford, 2000). The project is said to be intended to help restructure Ghana's research establishment in order to enable it to respond to the needs of the private sector and to enhance the competitiveness of Ghanaian industry. Ghana's Council for Scientific and Industrial Research (CSIR) component of the PSDP involves the restructuring of three industry-related CSIR institutes (which include the Institute of Industrial Research, the Food Research Institute and the Building and Road Research Institute) and the CSIR Secretariat, as well as the commercialisation of their operation. Of course, this coincided with the passing of a new Act re-establishing the CSIR (Act 521 of 1996). The new operational purview of the Act is demand-driven and commercialised research, exemplified in such procedures as contract research, consultancies, sales of technical services, and commercial exploitation of research findings and products. A small fund (3.3 million) was also made available to provide matching grants for the cost of consulting and services for small and medium enterprises (see also Crawford and Brezenoff, 2001; CSIR, 1998:2).

4.3.6.2 Summary of World Bank's Operational Supports for S&T Projects

Table 4.6 below shows the tabulation of the various projects and the amount lent to the various African countries to support S&T activities. Tunisia's loan of $75 million was the highest figure, followed by $65 million to Algeria, with Kenya securing the third highest. The rest were granted loans equal to $30 million or less.

TABLE 4.6: World Bank support for S&T projects in Africa 1980-1999 (excluding Agriculture)

FY	Loan US$ Millions	Country	Project
95	13	Ghana	Private Sector Development
95	16	Mauritius	Higher and Technical Education
94	7.7	Mauritius	Technical Assistance to Competitiveness
92	55	Kenya	University Investment
92	75	Tunisia	Higher Education Restructuring
91	65	Algeria	Science and Technology University Development
90	30.5	Egypt	Engineering and Technical Education

Source: Compiled from Crawford and Brezenoff, 2001.

By 1985 the Bank had invested more than $5 billion in about 260 education projects in more than 90 countries. This investment has aided in providing a total of 3 million school, college or university places in more than 20 000 institutions (Psacharopoulos & Woodhall, 1985:4). Between 1963 and 1975, the Bank supported 34 projects or project components directed at universities, with most (102) being higher education projects or project components supporting teacher training, technical or polytechnic institutions. Still, university projects accounted for a majority (54%) of World Bank lending for higher education. In a study Thulstrup (1993) argues that the support for S&T in higher education projects has increased significantly since 1980, especially in Asia, where the total project costs grew from $131 million in the 1970s to $4,525 million ($1,334 million in loans) in the 1980s (see Muskin, 1992). All other regions, especially Africa, received much less. Thulstrup contends that globally World Bank project costs for science and technology in higher education are now expected to amount to between $500 million and $1 billion annually and the regional distribution, at least outside Africa, is expected to be even more.

For instance, among 32 higher education science and technology projects that were initiated between 1970 and 1991 about one third had explicitly stated research and development objectives. Such components occurred in all regions except Africa, where none of the four projects contained research objectives. The greatest expenditure in the projects was for building and equipment, which on average accounted for around one third each of the total. Amongst the other budget items graduate training, especially overseas, was the largest. Operation and maintenance were also given considerable resources (Thulstrup, 1993).

Most projects aimed at direct support for industry had scientific research components (Muskin, 1992). Thulstrup (1993) asserts that, among 13 projects supporting science in industry that were initiated between 1970 and 1991, essentially all had clearly stated research objectives. Twelve of them supported research institutions and 5 supported universities. However, none of these projects was based in the African region. The total costs for the projects were over $2 billion; about half of this amount came from World Bank loans. As in education, lending for science in industry is expected to increase; the projected annual costs for industry science and technology projects during the 1990s are estimated at $400 million. In comparison with the higher education projects, much less was spent on building (7%), while a similar share (one third) was spent on equipment. An activity not included in any of the university projects, on-lending, here in support of projects in individual industries, was given 26% of the funds (Thulstrup, 1993).

In another study Eisemon and Holm-Nielsen (1995) note that the World Bank's lending for higher education and science and technology development has also increased considerably. They state that "Between 1970 and 1991, lending for higher education amounted to US$5.0 billion, of which 50% was lent between 1985 and 1991. The science and technology component of higher education lending amounted to US$2.16 billion, of which 63% was also invested between 1985 and 1991. Over the same period, lending for science and technology in industry totalled US$1.0 billion, of which 81% was lent between 1985 and 1991". They assert that this growth was a reflection of the global trend that development is increasingly knowledge-driven.

In regional terms, which are reflected at the global level, East Asian countries accounted for 34 percent of recent higher education lending between 1986-1991, although this figure is down from 71% in the early 1980s. In fact, China alone borrowed heavily to assist the strengthening of 124 universities in the basic sciences and technologies (Jones, 1992:xv-xvi). However, it was not until the 1980s that programme lending in education became of interest, with its accompanying concerns for the processes of education, and its relevance and quality, which had hitherto tended to be the subject of a rather weak covenant (Jones, 1992:17). Project lending was introduced under the presidency of Tom Clausen (1981-6), and was considered to enable the Bank to address in a significant way *through its lending* the structural problems underlying underdevelopment. This, however, constituted only 20% of the total bank lending (Jones, 1992:17). Lending to South Asian and European and Middle Eastern countries has also increased. South Asia's share increased from 4 percent to 20 percent of lending from 1981 to 1986-1991. However, the lending component for higher education in loans to African, Latin American and Caribbean countries has diminished, relatively speaking. For example, African countries accounted for almost half (43%) of all higher education components in the 1960s. Africa's share of higher education has decreased to 11 percent since 1986, while Latin American and Caribbean countries accounted for only 7 percent of higher education lending during this period, and just 6 percent for the period 1963 to 1991 (Eisemon & Holm-Nielsen, 1995).

On the one hand, Table 4.7 indicates the number of institutions supported by the World Bank's educational lending programme between 1963 and 1991. Within this period, teacher-training institutions accounted for 34% of all projects funding and the universities 28% funding support for projects. S&T research institutes accounted for 4% and covered 17 institutes 13 of which were supported between 1986 and 1991. On the other hand, Table 4.8 shows the Bank's support for both education and industry between 1970 and 1991, while Table 4.9 illustrates the regional patterns of distribution of the Bank's lending within the same period of time. The Bank has had a Special Representative for Africa since 1961.

TABLE 4.7: Number and kinds of higher education investments, 1963-1991

Institution	63-70		71 - 75		76 – 80		81 - 85		86 - 91		Total	
	No.	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Universities	10	29	25	26	26	26	23	26	28	34	122	28
S&T Research Institutes	0	0	1	1	0	0	3	3	13	12	17	4
Polytechnics	3	9	9	9	6	6	9	10	10	9	37	9
Technical Institutes	7	20	30	31	34	34	19	22	17	15	107	25
Teacher Training Institutions	15	43	33	34	34	34	34	39	33	30	149	34
Total	**35**	**100**	**98**	**100**	**100**	**100**	**88**	**100**	**111**	**100**	**432**	**100**

Source: Eisemon and Holm-Nielsen, 1995

TABLE 4.8: World Bank support of science and technology projects for higher education and industry, by five-year segments

Higher education					
Fiscal Year	***No. of Projects***	***Total (US$ M)***	***(%)***	***Loan (US$ M)***	***(%)***
1970-74	4	197.5	3.2	78.1	3.6
1975-79	3	170.4	2.8	93.4	4.3
1980-84	6	2129.5	34.6	637.4	29.5
1985-89	12	2871.3	46.6	842.7	39.0
1990-91	7	789.7	12.8	511.0	23.6
TOTAL	32	6158.4	100.0	2162.6	100.0
Industry					
Fiscal Year	***No. of Projects***	***Total (US$ M)***	***(%)***	***Loan (US$ M)***	***(%)***
1970-74	0	-	0	-	0
1975-79	2	143.0	6.9	109.0	10.8
1980-84	2	92.0[a]	4.5	85.0	8.4
1985-89	7	1222.7	60.0	510.5	50.3
1990-91	2	585.2	28.6	309.2	30.5
TOTAL	**13**	**2042.9[a]**	**100**	**1013.7**	**100**

[a] The total project could be determined from the appraisal report of the project.

Sources: World Bank Lending for Science and Technology: General Operational Review (Muskin, 1992:2).

TABLE 4.9: Regional distribution of World Bank support of science and technology projects for higher education and industry

Higher education					
Region	***No. of Projects***	***Total (US$ M)***	***(%)***	***Loan (US$ M)***	***(%)***
Asia	19	5044.8	81.9	1623.8	75.1
Asia less Korea, Indonesia & China	(4)	(127.5)	(2.1)	(65.4)	(3.0)
Africa	4	100.6	1.6	78.0	3.6
EMENA	7	498.1	8.1	238.8	11.0
Latin America	2	515.4	8.4	222.0	10.3
TOTAL	**32**	**6158.4**	**100.0**	**2162.6**	**100.0**
Industry					
Region	***No. of Projects***	***Total (US$ M)***	***(%)***	***Loan (US$ M)***	***(%)***
Asia	8	1271.1	62	675.7	66.6
Asia less Korea, Indonesia & China	(1)	(410.0)	(20.1)	(200.0)	(19.7)
Africa	0	0	-	0	-
EMENA	4	691.8[a]	33.9	258.0	25.5
Latin America	1	80.0	3.9	80.0	7.9
TOTAL	**13**	**2042.9[a]**	**100.0**	**1013.7**	**100.0**

[a] The total project cost could not be determined from the appraisal report of the project.

Sources: Muskin (1992:7; 1997)

However, the problem with the above tables, as Eisemon and Holm-Nielsen (1995) explain, is that they excluded agricultural research in their analysis. The financial assistance to Kenya and Zambia supporting agriculture is excluded. It also means that the Bank's involvement in agricultural research, which began in 1971 with support for two important projects, is neglected in these studies. For instance, while Spain is not an African country, in 1971 the Bank provided a $12.7 million loan to Spain to help finance the reorganisation of agricultural research and development activities for the whole country. The project included the establishment of six research centres oriented to a major commodity that was considered important to the national economy. This happens to be the first World Bank Group loan that was made primarily for the conduct of research in any field. Besides, one quarter of the project funds were also meant for technical assistance, including the international recruitment of research specialists and consultants, as well as 200 overseas training fellowships for Spanish scientists (see World Bank, 1971:7).

In this regard the most recent review of the Bank's operational support for S&T over a period of two decades is worthy of note. Crawford and Brezenoff (2001) have reviewed 590 projects involving support to improving S&T capacity in the period between 1980-1999 and their *main findings* are:

A. A substantial number of projects (1 out of every 8) provide support to S&T capacity building in some, but only 1 in 50 projects is principally concerned with improving S&T:

- projects (12.3% of all World Bank projects) over the past two decades provide some support for S&T. However, fewer than 100 projects (2.1% of all lending) were dedicated primarily to promoting S&T and/or contain a significant S&T component. The total cost of the 590 projects was US$72.6 billion, of which US$17.1 billion (24%) was invested in S&T improvement activities;

- in nearly half of all projects the S&T component was less than US$3 million; only 13% of the projects devoted more US$50 million to S&T activities. Of projects providing only "minor support" to S&T, the vast majority were in the agricultural sector.

B. Most major support for S&T (outside of Agriculture) went to a handful of large, middle-income countries.

- Over 50% of the "major" S&T loans (non-agriculture) went to only six countries. Twelve countries took about 75% of the loans; the remaining 25% were divided among fourteen countries.

C. The Agriculture, Education, and Private Sector Development Sectors account for almost all of the major support to S&T:

- the agriculture sector accounts for about 42% of all major S&T projects. The remainder consists of the other sectors combined, but predominantly education and industry.

D. East Asia and Latin America were the dominant borrowers:

- In terms of regional distribution, East Asia received half of all major loans during the review period. The next most frequent S&T borrower, Latin America, took out nearly one-fifth of the loans, and the remainder was divided among the other four regions.

Secondly, as we have already mentioned in Chapter Three, a tentative attempt was made at the international level by the Bank, together with other international organisations including the United Nation's Food and Agricultural Organisation (FAO), the United Nations Development Programme (UNDP) and other governmental and non-governmental institutions in sponsoring the consultative group of agricultural research which is of major concern to developing countries. This has created some international and regional centres for research, which are of relevance to our study.

The Crawford and Brezenoff (2001) analysis of Bank lending for S&T for the fiscal years 1980-99 reveals that a total of 102 major S&T projects were approved by the Bank, of which 43 were for Agricultural S&T while 59 dealt with other sectors. The 59 non-agricultural S&T projects accounted for nearly US$ 5.4 billion (1.4%) of the total US$ 381.8 billion lent by the Bank during that period. There were on average about 3 S&T projects per year, which represented 1.2% of all projects; with an annual average lending of US$268, or US$ 91 per project for S&T. Like the earlier studies, this study also reveals a regional bias towards the East Asia region, which had 29 of the 59 projects listed. Latin America followed with the second largest percentage (11 projects), Europe and Central Asia with 7 projects were third, the South Asian region had five projects; Africa had four; and MENA had three projects during the 1980-1999 period. However, in terms of lending volume, the African region had the smallest percentage, with only 2% of the finance approved by the Bank (see Crawford & Brezenoff, 2001).

4.3.7 African Virtual University programme

We have tried to look at the World Bank lending for science and technology programmes and have so far noticed that not much has been lent to Africa. Whether lending for the building of scientific infrastructure, for manpower training or for research, Africa lags behind on all fronts and in all regions. This problem has finally been recognised by the World Bank, which has led to the Bank's support for the African Virtual University (AVU) programme in 1997. In fact, in launching the African Virtual University, the proposal to the World Bank (1996) describes the position of science and technology in Africa as follows: "Sub-Saharan Africa's ability to actively participate in the new global economy and to solve the many social and political problems that it faces depends largely on the intellectual capacity and skills of its labour force, particularly in the fields of science and technology and business. This implies that there must exist a cadre of professionals from a broad range of disciplines who are skilled in using and adopting existing and new knowledge and information to changing local, national and international conditions". While acknowledging that Africa has made some progress towards building a critical human resource base, for example, between 1980 and 1989 the percentage change was 56% – more than in any other developing region – it still, however, falls far behind these other developing regions in terms of the university student training per 100, 000 population as shown in Table 4.10 below. This is a major rationale for an AVU.

TABLE 4.10: University students per 100 000 persons in developing regions

Region	1980	1989	% Change
Sub-Saharan Africa	104	162	56
Asia	535	645	23
Latin America	1,352	1,659	21
Arab Sates	901	1,093	21

Source: African Virtual University http://www.avu.org/avusite/about/concept.htm

Therefore, the main objectives of the AVU concept as proposed were to provide access to education in S&T on a grand scale using, "the power of information technologies to deal with the challenge of bringing to the market a large number of well-trained African scientists, technicians, engineers, business managers and employees. AVU will tap the potential offered by the new technologies to overcome the financial, physical and information barriers that prevent increased access to high quality education in SSA. The strength of the organisation will lie in its ability to adapt to the demands of the marketplace".[7] The programme is designed to bring to Africa Western-level courses in computer science and business management (Turner, 1999).[8] Under the programme participating university students often watch either live or pre-recorded lectures over a two-way satellite link (i.e. via video-conferencing and other internet technologies) with learning institutions in North America and Europe. The students will also gain access to an on-line virtual library and write assignments for both foreign and domestic teachers.

Through its Information for development (Info-Dev) programme, the World Bank accepted the proposal and launched the first pilot project at the Kenyatta University, Nairobi (Kenya) in July 1997. The programme has expanded to include 26 universities in 15 anglophone and francophone countries.[9] AVU offers pre-degree courses and seminars. The pilot projects in all

[7] See AVU "The Project Concept" http://www.avu.org/avusite/about/concept.htm.
[8] Turner, Mark "Virtual learning spurs Africa's universities" The Financial Times (London) 26 February 1999 (http://www.avu.org/uf/ft.htm).
[9] The universities are: Addis Ababa University (Ethiopia), University of Ghana, University of Cape Coast and Kwame Nkrumah University of Science and Technology (Ghana); Egerton University, Kenyatta University (Kenya); University of Namibia (Namibia); Technikon Southern Africa and University of Pretoria (South Africa); The Open University of Tanzania and The University of Dar-es-Salaam (Tanzania); Makerere University, Uganda Martyrs University and Uganda Polytechnic (Uganda); National University of Science and Technology and University of Zimbabwe (Zimbabwe), all anglophone countries. Others are: Université nationale du Bénin (Bénin); Université d'Ouagadougou (Burkina Faso); Chamber of Commerce and UVA Notre

sites have been completed at a cost of US$6.5 million funded through grants by the World Bank and other bilateral donors and support from the private sector.

With the completion of the pilot phase, AVU has now moved from a World Bank programme to establishing itself as an independent non-profit organisation with its headquarters in Nairobi, Kenya. AVU started offering courses in two main streams:

- *The Business and Technology Channel*, which delivers short courses in management and information technology (IT) and foreign languages (as of October 2000).
- *The Academic Channel,* which will offer undergraduate degrees in computer science, computer engineering and electrical engineering (as from October 2001).[10]

The lectures are delivered from the studio classroom of a world-class professor from sites in North America and Europe. The course is then transmitted to AVU's central uplink facilities in Clarksburg, Maryland (USA) and finally beamed by satellite to its learning centres in Africa. The centres, which are each equipped with an inexpensive satellite dish, receive the signal.

The accomplishments of the pilot programme include over 2500 hours of interactive learning instructions, in which more than 12 000 students have completed semester-long courses in engineering and the sciences. Over 2500 professionals have also attended executive and professional management seminars on topics that include Strategy and Innovation, Entrepreneurship, Global Competencies, e-commerce and Y2K. Through the AVU website students are provided with access to an on-line digital library with over 1000 full-text journals, and over 10 000 free e-mail accounts have also been provided.[11]

4.3.8 The Consultative Group on International Agricultural Research and SPAAR

The development of improved agricultural technology in Africa and other tropical areas is not a new phenomenon, neither is the idea of regional centres of agricultural research, which have been prevalent for decades, particularly during the colonial era. The lack of a sufficient food supply system in the developing countries prompted the setting up of international agricultural research centres in the 1960s. These include the International Rice Research

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Dame de Tendresse (Burundi); Université deNouakchott (Mauritanie); Université de Niamey (Niger); Universite Nationale du Rwanda and University of Kigali (Rwanda); and Université Gaston Berger and Université de Dakar (Senegal), all francophone countries.

[10] AVU http://avu.org/about/index.htm.

Institute (IRRI 1960) in the Philippines, with financial support from the Ford and Rockefeller Foundations. Then in 1966, through its programmes, the Rockefeller Foundation established the International Maize and Wheat Improvement Centre (CIMMYT) in Mexico (Coulter, 1984:266). Furthermore, in 1967 a tentative decision was taken by the two Foundations to establish two more institutes, namely the International Institute of Tropical Agriculture (IITA) in Nigeria and the International Centre for Tropical Agriculture (CIAT) in Colombia, which were completed in 1970 and 1971 respectively.

However, the cost of funding these institutions increased enormously and there was a need for sustained long-term funding that would complement these private efforts by the international community and foster co-operation. As a result the Bank undertook an extensive series of consultations on this problem with the Foundations that had already taken the lead in the field as well as with other international organisations and national aid agencies concerned with promoting agricultural productivity in developing countries. On the basis of these consultations and explorations, the President of the Bank proposed to the Executive Directors that a consultative group be formed under the co-sponsorship of the Bank, FAO and the UNDP to consider on a continuous basis the financial and technical requirements for international agricultural research and to organise the necessary wherewithal in support (World Bank, 1971:33).

A preliminary meeting was held in January 1971 consisting of governments and other interested parties willing to organise such a consultative group; it included 17 governments, 3 private foundations, the International Development Research Centre of Canada, and the Development Assistance Committee of the Organisation for Economic Co-operation and Development (OECD). It was agreed that a Consultative Group on International Agricultural Research (CGIAR) should be created. In May 1971 the Group held its first meeting at the Bank's headquarters which dealt exclusively with organisational matters such as the composition, objectives and organisational structure of the Group. It was also agreed at the meeting that up to five developing countries be invited to take up membership for two-year terms, each representing a major geographical region, with FAO working out the procedures (World Bank 1971:33).

[11] AVU http://avu.org/about/index.htm.

Although membership does not involve a commitment to provide funds, a number of members have indicated the order of magnitude of financing which they are prepared to make available under certain conditions. With the approval of the Executive Directors, the Bank Group announced at the first meeting that it would consider providing an amount of up to $3 million in grants for the calendar year 1972 to assist activities supported by the Consultative Group, provided the requisite funds could not be raised from other sources (World Bank, 1971:33).

In its work to determine the gaps in – and priorities for – agricultural research needed for the benefit of developing countries, especially at the regional and international levels, a Technical Advisory Committee (TAC) assists the Consultative Group. The Committee consists of 12 internationally distinguished scientists under the chairmanship of John Crawford of Australia. Six of the members are nationals of the developing countries. The Bank Group provides the Secretariat for the CGIAR, and the FAO that for the Technical Advisory Committee. Subject to required budgetary approval, the three co-sponsors – FAO, UNDP and the Bank – shared the cost of the TAC and of individual specialists advising the Committee.

Therefore, at the initiative of the World Bank, the CGIAR was to help broaden the support for international programmes on research and training aimed at increasing the quantity and improving the quality of food production in developing countries. Hence the CGIAR was created as an association of international and regional organisations, national governments, public and private foundations and representatives of developing countries (Coulter, 1984:267).

The United Nations Food and Agricultural Organisation (FAO), the International Fund for Agricultural Development (IFAD), the United Nations Development Programme (UNDP) and the World Bank jointly sponsor the CGIAR Group. The Bank provides the chairman and the executive secretariat. A panel of experts – the Technical Advisory Committee (TAC), whose secretariat is provided by FAO – advises the CGIAR. The CGIAR has grown from 20 in 1971 to 58 members comprising 22 developing and 21 industrialised countries, 3 private foundations, and 12 regional and international organisation in 2001, that provide funding, technical support, and strategic direction. Its activities and international centres now known as the "Future Harvest Centres" has increased from 4 to 16, and the financial contribution from 'US$20 million in 1972 to approximately US$145 million in 1982' (in current dollars)

(Coulter, 1984). It currently operates with about a US$340 million annual research budget in 2001, thus representing an increase of more than 40 per cent since the early 1990s.[12]

Since it first came into existence the TAC has helped review the needs of international agricultural research and training as well as identified the most serious gaps and shortcomings in terms of both food crops requiring attention and ecological zones in the South on which farming systems research was needed. These reviews have led to the establishment of the16 international agricultural research centres, four of which are in Africa, which include:

1. International Centre for Tropical Agriculture (CIAT), based in Call (Colombia), which deals with cassava, field beans, maize, and rice. It also includes the production systems for cattle and swine;

2. International Centre for International Forestry Research (CIFOR), based in Bogor (Indonesia), is a global knowledge organisation which is committed to enhancing the benefits of forests for people in the tropics through collaborative strategic and applied research; and related activities in forest systems and forestry, promoting of the transfer of appropriate new technologies as well as the adoption of new methods of social organisation for national development.

3. International Maize and Wheat Improvement Centre (CIMMYT), based in Mexico City (Mexico), which covers research on breeding improved varieties of maize and wheat as well as research on barley, triticale (a cross between wheat and rye), and sorghum;

4. International Potato Centre (CIP) located in Lima (Peru), which serves potato-growing areas in all developing regions;

5. International Centre for Agricultural Research in the Dry Areas (ICARDA), located in Aleppo (Syria), which deals with crop improvement (barley, broad beans, lentils and durum wheat) soil and water management, and farming systems (including sheep husbandry) for dry, winter-precipitation areas;

6. International Centre for Living Aquatic Resources Management (ICLARM), based in Penang (Malaysia), has been established to conduct, stimulate and accelerate research

[12] CGIAR Members http://www.cgiar.org/members/index.html

relating to all aspects of fisheries and other living aquatic resources in tropical developing countries.

7. International Centre for Research in Agroforestry (ICRAF), located in Nairobi (Kenya); it conducts both strategic and applied research and currently has five main research and development themes: diversification and intensification of land use through domestication of agroforestry trees; soil fertility replenishment in nutrient-depleted lands with agroforestry and other nutrient inputs; socio-economic and policy research to allow policies that will benefit smallholder farmers; acceleration of impact on farm by ensuring that research results are used; and capacity and institutional strengthening through training and the dissemination of information.

8. International Crops Research Institute for Semi-Arid Tropics (ICRISAT), located in Patancheru (India), which deals with the development of farming systems in semi-arid zones and with the development of improved varieties of groundnut, sorghum, millet, chickpea, and pigeon pea;

9. International Institute of Tropical Agriculture (IITA), based in Ibadan (Nigeria), which is concerned with the development of farming systems for the humid and sub-humid tropics, as well as with cassava, cowpea, plantain and banana, soybean, yam and local adaptations of internationally and nationally developed strains of maize and rice;

10. International Livestock Research Institute (ILRI), located in Nairobi (Kenya), which deals with research to enhance the production of livestock by small scale farmers in the tropics. For example, it studies two major protozoan diseases of cattle in certain parts of Africa, trypanosomiasis and theileriasis (East Coast fever);[13]

11. International Plant Genetic Resources (IPGR), which was established in Rome (Italy), and seeks to stimulate and co-ordinate the collection, preservation, evaluation and exchange of a wide range of genetic materials of many species of potential interest to plant breeders in the developing countries;

[13] ILRI began operations in 1995 following the consolidation of staff and facilities of two former CGIAR centres in Africa: the International Laboratory for Research on Animal Diseases (ILRAD), based in Nairobi, Kenya and the International Livestock Centre for Africa (ILCA), which was based in Addis Ababa, Ethiopia.

12. International Food Policy Research Institute (IFPRI), located in Washington DC (USA), which works on analysis of world food problems to determine those actions and policies that could be adopted by governments and international agencies to increase the supply of food.

13. International Rice Research Institute (IRRI), located in the Los Banos (Philippines), whose major responsibility is the development of improved varieties of rice and related farming systems;

14. International Service for National agricultural Research (ISNAR), with its headquarters in the Hague (Netherlands), provides assistance to developing countries for planning, organising and managing research more effectively;

15. International Water Management Institute (IWMI), located in Colombo (Sri Lanka), aims at improving water and land resource management for food livelihoods and nature. It has five research and development themes: integrated water resources and management for agriculture, sustainable smallholder land and water management, sustainable groundwater management, water resource institutions and policies and water health and environment.

16. West African Rice Development Association (WARDA), located in Boauké (Côte d'Ivoire) after its principal location was moved from Liberia, which deals with rice research and development in Sub-Saharan Africa. WARDA comprises 17 member states mostly in West Africa.

Then in 1985 the World Bank specifically helped in mobilising donors which led to the creation of the Special Programme for African Agricultural Research (SPAAR). This was encouraging. However, the SPAAR programme has come to end and through the initiatives of the World Bank and other sponsors as well as the sub-regional agricultural research organisations in Africa, it is to be replaced by the Forum for Agricultural Research in African (FARA), which will be based in Africa at the FAO regional office in Accra, Ghana. FARA which was established in 1997 as regional Forum is to provide support to the three main sub-regional agricultural research organisations (ASARECA, CORAF and SACCAR), with the aim of strengthening and integrating of national agricultural research systems (NARSs) at the sub-regional, increase collaboration between them and international agricultural research centres (IARCs) and Advanced Research Institutes (ARIs), with particular attention to networking.[14]

4.3.9 Evaluation

In trying to apply knowledge-based development theory using the four main indicators which we discussed in Chapter Two of this study, we can first and foremost argue that, through the lending patterns of the Bank, it has failed the African region when it comes to support for infrastructure development, particularly at the higher education level, as well as in building research centres for S&T. The lack of the Bank's support for educational infrastructure in Africa at this level implies that national capability building is inadequate. This is closely linked to the low level of S&T skills development in the continent. However, the Bank's involvement with the CGIAR system means that agricultural science is what has interested it most, as is shown by the SPAAR programme. Still, its support for agricultural credit has been decreasing. As the Millennium African Plan (MAP) document notes, "too little attention has been paid recently by bilateral donors and multilateral institutions to the agricultural sector and rural areas, which contain 70 percent of the poor people in Africa. For example, in the World Bank portfolio, credits to agriculture amounted to 39 percent in 1978, but dropped to 12 percent in 1996 and even further to 7 percent in 2000" (MAP, document 2001; see also Paarlberg, 2000:36).

As part of refocusing the Bank's attention on S&T, there have been calls for the establishment of a Central Unit within the Bank to deal with issues of S&T for development (Muskin, 1992; Crawford 2000; Crawford & Brezenoff, 2001). The functions of such a Unit will include:

- support in those cases where countries request assistance for (fundamental or cross-cutting) S&T programmes;
- promotion by the Bank of networking and co-operation on multisectoral S&T issues;
- provision of highly specialised resources to deal with cross-cutting S&T issues such as intellectual property rights, standards and the ethical conduct of research;
- provision of Bank-wide support, where needed, for critical technologies (e.g. biotechnology, materials technology);
- provision of experts in the economics and management of research;

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[14] GFAR and FARA http://www.worldbank.org/afr/aftsr/arg&fara.htm

- assisting sector staff in developing sectoral S&T units where needed (perhaps in a manufacturing environment);
- helping sector staff examine or re-examine S&T strategy within the Bank's sector programmes;
- supporting the Bank's S&T projects in non-sector-specific areas, such as basic research infrastructure and the development of national IPR and standards and mensuration institutions (Daly, 2000).

When the UNESCO-World Bank Co-operative Agreement was signed in June 1964, it's wording reflected nothing high-minded about the benefits of international programming and inter-agency collaboration. The Co-operative Agreement made provision for the Bank and UNESCO to work together on most of the project cycle - identification, preparation, appraisal, implementation, end-use supervision and technical assistance. Allocation of functions was more specialised, with UNESCO having primary responsibility for project identification and preparation, and the provision of technical assistance to project implementation, while the Bank remained responsible for appraisal and end-use supervision all in the field of education. Nonetheless, for each functional area, formal provision was made for collaboration. Early co-operation with the Bank led to joint funding of the International Institute for Educational Planning in Paris (Jones, 1992:71-72). The agreement was abandoned in 1986. It is prudent to argue that given the level of inter-institutional co-operation between the Bank and UNESCO, there are arguments for shared responsibility in neglecting S&T in Africa before the abrogation of their co-operation agreement. Both institutions have largely focused on basic education, while not sustaining the development of higher education, especially in science, technology and engineering.

The African continent continues to be the least developed, with most of the least developed and poorest countries (of the 49 least developed countries in the world today 34 are in Africa) (UNCTAD, 2001). The introduction of policy-based lending in the 1980s by the World Bank and other development finance institutions has not helped Africa in terms of developing the relevant human resources necessary for its participation in the current knowledge-based development economy. The support for higher education, science and technology in Africa has been very weak. It therefore comes as no surprise that the Bank appears to be trying to redeem its image through the AVU programme. How this programme is going to be sustainable is still not very clear.

The liberalisation process has yet to bring about greater private sector participation in improving the scientific infrastructure, as well as in research and development, even in the agricultural sector (see for example, Pray & Umali, 1998). Besides, although the Bank Group has been involved in agriculture and rural development, its support for the sector has been decreasing over the years, something which affects Africa badly.

Calling itself a knowledge institution means that the Bank will have to address the fundamental question of assisting the financing of S&T in more meaningful ways in Africa. Internal sources at the Bank indicate that it is planning to play such a role through support for the establishment of science and technology centres of excellence, through what it calls the Millennium Science Initiative (MSI). The MSI projects are to provide targeted support which will focus on three areas: research excellence; human resources training; and linkages to partners in the international science community and the private sector. The MSI project was approved in 1999 for Chile. The Bank argues that it expects the MSI programme to become a major instrument for addressing the widening gaps in S&T that exist between the rich and the poor countries.[15] However, it remains to be seen how many such projects will be supported in Africa. After all, the Bank's lending for education and industry has always marginalized Africa in the past.

Furthermore, besides the MSI, the Bank notes that it is reformulating its strategy to science and technology in a number of sectors. It is also forming active partnership with organisations including UNESCO, the Third World Academy of Sciences, and the International Council of Scientific Unions (ICSU), in order to improve the scientific and technological capacity for economic growth and reduce poverty in developing countries.

Whatever problems precipitated the abrogation of its earlier collaborative agreement with UNESCO, we hope that this new partnership will work better. Most importantly, UNESCO is seriously advocating an approach to finance S&T through "science for debt-swap" in developing countries in the current debt forgiveness debate or the HIPC Initiative. However, we also have to bear in mind that the traditional overseas programme which World Bank loans supported often provided more support for universities in industrialised countries than the domestic, developing country universities, which frequently benefit little during the

[15] "Knowledge about technology" http://www.worldbank.org/extdr/gc/knowledge_tech.htm.

period of overseas studies for students, as these institutions are not much involved in the planning process, even when it is their own staff members who are be trained (Thulstrup, 1993).

Conclusion

Since the World Bank took the initiative in the 1970s to support S&T through the establishment of an S&T Unit, its support for science and technology has been modest, especially in Africa, particularly for human resources development and in support for R&D projects and programmes. Africa has been the recipient that has received the least in science and technology project lending. This means that the national S&T infrastructures which currently exist in most African countries were developed independently, or with other bilateral assistance. Even the SPAAR programme, which supports national agricultural research systems (NARS), has not brought about any significant changes in agricultural research and development at the national level in most African countries. The Bank's focus on basic education has also meant that high-level manpower training was much neglected, but the sustainable development of Africa cannot be based on basic skills development alone.

The introduction of policy-based lending since the 1980s has not brought about the necessary improvement in scientific and technological capacity. Private sector involvement, even in agriculture, has yet to be seen. Although the AVU programme is seeking to address some of the problems of science and engineering education in Africa, the sustainability of this programme is still not certain. It is hoped that, through the Bank's Millennium Science Initiative, Africa will be supported especially in programmes that will greatly enhance regional S&T development and co-operation.

4.4 THE UNITED NATIONS ECONOMIC COMMISSION FOR AFRICA AND TECHNO-REGIONALISM

4.4.1 Introduction

The United Nations Economic Commission for Africa (ECA) was established on 29 April 1958, in terms of Resolution 671A (XXV), adopted by the United Nations Economic and Social Council (ECOSOC). It is considered as the regional arm of the United Nations, which is mandated to support the economic and social development of its 53 Member States, foster regional integration and promote international co-operation for the development of Africa

(ECA, 1999:7). The ECA also represents one of the five regional economic commissions which have been established by ECOSOC between 1947 and 1974. These include the Economic Commission for Europe, the Economic Commission for Asia and the Pacific (formerly the Economic Commission for Asia and the Far East), the Economic Commission for Latin America and the Caribbean (formerly the Economic Commission for Latin America), and the Economic Commission for Western Asia (now the Economic and Social Commission for Western Asia) and, lastly, ECA. This was in response to the need for economic development and growth-promoting institutions in the five major regions of the world, under the aegis of the United Nations (Asante, 1991:19). The ECA, like all the other regional commissions, is under the general supervision of ECOSOC and the United Nations General Assembly.

The main terms of reference for ECA, as laid down by ECOSOC, require the Commission to initiate and participate in measures for facilitating concerted action to relieve the economic and technological problems and promote the development of Africa; to make or sponsor investigations into economic and technological problems and development within the countries of Africa; to undertake or sponsor the collection, evaluation and dissemination of such economic, technological and statistical information as the Commission deems appropriate; to perform such advisory services as the countries of the region may desire, provided that these do not overlap with those provided by other bodies of the United Nations or by its specialised agencies; to assist the Economic and Social Council, at its request, in discharging its functions within the region in connection with any economic problems including those in the field of technical assistance; to assist in the development of co-ordinated policies for promoting economic and technological development in the region; and to deal where appropriate with the social aspects of economic development and with the relationship between economic and social factors (UN document 14/424, UN Economic Commission pp. 3-4 cited in Asante, 1991:19-20).

In order to pursue its main objectives and to carry out the tasks entrusted to the Commission, the ECA has organised its secretariat into divisions with four main functions:

1. to organise conferences, meetings and seminars to exchange knowledge and experience on ways to solve Africa's socio-economic problems;
2. to provide advisory services through regional advisers to governments and their

intergovernmental organisations, at their request, in the fields of activity in which they are concerned;

3. to organise training courses for African nationals to acquire skills and experience in order to speed up the Africanisation of public services;

4. to collect, collate and disseminate statistical information and also to conduct and publish the results of such economic surveys and analytical studies (Asante, 1992:20).

The development of Africa is not dependent on only a few projects, but will require important growth in ideas, institutions, skills and activities. Skilled manpower problems in Africa led the ECA to initiate three main programmes: 1) training through awards of fellowship; 2) training workshops and seminars; and 3) the establishment of training institutions. A report prepared by SKB Asante on behalf of ECA states that by 1968, i.e. a decade after its establishment, a total of 1600 statistician-economists, junior statisticians, assistants and technical agents had been trained for employment, while 240 statistical economists and 200 assistants and technical agents were in training (Asante, 1992:26).

Economic co-operation and institution building have been some of the major tenets of the Commission's developmental approach in Africa. Therefore, from its first session it placed the emphasis on the need for co-operative action among African countries in practically every economic sector. For instance, institution building is considered as part of the necessary infrastructure for social and economic development (Asante, 1992:26).

According to Asante (1992:29), after the inception of ECA in 1958 the first 15 years were not as forward looking as the mid-1970s, which saw the reorientation of its activities. These included:

- the acceleration of integration of women in development following the establishment of the African Training and Research Centre for Women (ATRCW) in 1975;
- the streamlining of the organs of the ECA and decentralisation of its structure through the establishment of the Multinational Programming and Operation Centres (MULPOCs) in 1977-8;
- the establishment in 1977 of the United Nations Trust Fund for African Development (UNTFAD), as a significant step in the direction of self-reliance;

- the launching of the United Nations Transport and Communication Decade for Africa (1978-88);
- the emergence of ECA as a major executing agency within the UN system;
- the preparation of the Monrovia Strategy for the Economic Development of Africa and the Lagos Plan of Action, the African Priority Programme for Economic Recovery and also the African Submission on the UN General Assembly Special Session on the Critical Economic Situation in Africa;
- the launching of the Industrial Development Fund;
- the promotion of regional co-operation through the setting up of appropriate sub-regional organisations and institutions in the Western, Eastern and Southern Central African sub-regions and for the Great Lakes States;
- the establishment of the Pan-African Development and Information System in 1981;
- the creation of a diversified group of specialised sub-regional and regional economic, training and research institutions spread across Africa to serve as a basic foundation of socio-economic development;
- the launching of the African Alternative Framework to Structural Adjustment Programmes for Socio-Economic Recovery and Transformation in 1988; and
- the Arusha statement on democracy at the start of the 1990s.

However, following the restructuring and rationalisation of the Commission (the process began in 1992), the Commission developed a Medium –Term Plan for (1998-2001) with each programme falling under one of the new programme division of the ECA Secretariat. These include:

- *Economic and Social Policy Analysis Division (ESPD),* which deals with the compilation and synthesis of available information on Africa, analysis of policies in critical sectors and dissemination of information throughout Africa on successful development policies and practices; with particular emphasis on social development and alleviation of poverty;
- *Food Security and Sustainable Development Division (FSSDD),* which deals with integration of policies in the inter-related issues of food security, environment, human settlements and population;

- *Development Management of Division (DMD),* which deals with strengthening member state's capacity in the management of the public sector, private sector and civil society;
- *Development Information Systems Division (DISD),* which deals developing information and communications infrastructure policies to improve quality of national statistics and enhance dissemination using electronic networks;
- Regional Co-operation and Integration Division (RCID), which deals with strengthening regional economic co-operation and integration of physical infrastructure (transport, communications and energy) and collaboration in minerals development;
- *Africa Centre for Women (ACW),* dealing with the promoting of the advancement of women in all aspects of Africa's development; and
- *Sub-Regional Development Centres (SRDCs),* dealing with the support for sub-regional activities for development based on the priorities specific to each sub-region.[16]

In this regard, the ECA is now providing the African member states not only with ideas, surveys and studies, but also serving them in terms of executing individual projects at the national, sub-regional, regional and interregional levels. In all, the ECA now considers its role in terms of four main clusters:

- Advocacy and Policy Analysis;
- Convening stakeholders and building consensus;
- Technical co-operation and capacity building;
- Enhancing the UN's role in Africa.

To carry out the above roles, the intergovernmental machinery of the ECA has also been streamlined and reduced to three which include: the Conference of African Ministers responsible for Economic and Social Development and Planning (the Commission) and its Preparatory Technical Committee of the Whole (TEPCOW), the Conference of African Ministers of Finance, and the Intergovernmental Committee of Experts of the Sub-Regional Development Centres (ICE). The ECA has further abolished all other Conferences of Ministers including three subsidiary bodies: United Nations Regional Cartographic Conference for Africa; African regional Conference on Science and Technology and Joint

[16] "Report of the Acting Director March 1997- October 1998" http://www.un.org/depts/eca/prog/srdc/sa/director.htm

Conference of African Planners, Statisticians, Population and Information Specialists. However, the ECA has created seven subsidiary committees (or expert-level bodies), namely: the Committee on Development Information, the Committee on Sustainable Development, the Committee on Women in Development, the Committee on Human Development and Civil Society, the Committee on Industry and Private Sector Development, above all the Committee on Natural Resources, Science and Technology, and the Committee on Regional Co-operation and Integration.[17]

4.4.2 ECA S&T Operations

Since its establishment the ECA has taken an interest in S&T; this gained momentum in the late 1960s and early 1970s with the strengthening of the role of the Commission in science and technology. In particular, during its second Ministerial Conference in February 1973 the ECA adopted the science and technology component of the African Strategy for Development in the 1970s. In resolution 248 (XI) of 22 February 1973, the Conference approved the African Regional Plan for the Application of Science and Technology to Development ARP), and established the Intergovernmental Committee of Experts for Science and Technology Development (IGCESTD) to pursue its implementation. The Intergovernmental Committee then held its first meeting after its formation in November 1973 in Addis Ababa, Ethiopia.[18]

Since its formation the Intergovernmental Committee has played a crucial role as a regional forum for realising a collective approach in S&T on various problems faced by the member states, thereby defining regional policies and strategies. The Committee has offered regular advice to the ECA secretariat on the needs and priorities of member states. In the run-up to the Vienna Conference on Science and Technology for Development, the Committee convened a meeting in Addis Ababa and formulated a regional policy framework and a programme of action in S&T, which was later useful in the preparation of the Lagos Plan of Action for the Economic Development of Africa in the 1980s as part of the chapter on science and technology. The heads of state and government of the OAU's Second

[17] "Report of the Acting Director March 1997- October 1998" http://www.un.org/depts/eca/prog/srdc/sa/director.htm
[18] ECA, "ARCST: Its Origin, Scope and Modalities of Work" http://www.sas.upenn.edu/African_Studies/Padis/padis6.html.

Extraordinary Session adopted the LPA in 1980.[19] Then in 1983, the Intergovernmental Committee of Experts on Science and Technology created five sub-regional working groups on S&T (Northern, Western, Central, Eastern and Southern), with a member State acting as co-ordinator or convenor for each group. According to the ECA (1995), the working groups meetings were instrumental in the identification of issues, problems and priorities and in the formulation of sub-regional policies and sub-regional projects that required collaborative actions. In spite of these actions on the part of the working groups, the ECA notes that they lacked some life of their own, as the continuity and follow-up actions and the raising of funds to realise sub-regional projects became difficult.

The early 1990s witnessed a number of initiatives for the restructuring of the ECA and an overall review of the intergovernmental machinery of the Commission. In particular, during the 19th meeting of the CEA Conference of Ministers in 1993, a resolution was adopted to upgrade the IGCESTD to an African Regional Conference on Science and Technology. Through the same resolution the technical advisory Committee on Nuclear Science and Technology in Africa was abolished and its functions integrated into the Regional Conference. The Regional Conference was assigned the following terms of reference:

- To assist the Commission in the definition and periodic review of strategies and programmes for the development and application of science and technology, including nuclear science and technology in Africa;
- To examine and advise the Executive Secretary on specific issues bearing on the implementation of such strategies; in general, as would actively pursue the promotion of science and technology and the formulation of measures to ensure their application to national, sub-regional and regional development;
- To give special consideration in its activities to the needs of the least developed member states, and to the application and impact of new and emerging technologies;
- To advise the Executive Secretary on ways and means of mobilising resources of all kinds for the implementation of strategies, programmes and projects for the development and application of science and technology within the region.

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[19] ECA, "ARCST: Its Origin, Scope and Modalities of Work" http://www.sas.upenn.edu/African_Studies/Padis/padis6.html.

In a June 1998 briefing on ECA activities on S&T in Africa to date the following areas were identified as having received the support from the Commission:

- assisting Member States in the formulation and implementation of regional, socio-economic and intersectoral aspects of S&T policies in Africa;
- bringing the socio-economic aspects of science and technology to the forefront of policies;
- promoting a better articulation of these policies with the overall development policies of Member States, including better linkages between sectors, going beyond policies which stress high-level training and public sector research only;
- launching or supporting policy dialogues and initiatives in science and technology in Member States for better management of science and technology
- initiating and executing carefully designed and cost-effective science and technology projects to meet the challenges of technological change and globalisation, in partnership with the private sector;
- effectively promoting support policies for the technological advancement of Member States and
- participating in collaborative activities with the UN Headquarters in New York, ECA-sponsored institutions, other UN Agencies and other regional sub-regional organisations

However, following the current restructuring of the ECA, S&T now falls under the Food Security and Sustainable Division (FSSDD). Previously S&T had fallen under the Natural Resources Division. The FSSDD efforts are aimed mainly towards the following four objectives:

1. to define the New Programme Focus and identify activities of the FSSD Division and disseminate this information to a diversified target audience;

2. to support the development of the African regional science and technology strategy and also other regional and sub-regional activities in pursuance of the identification of needs of the member States and the sub-regions;

3. to promote national and sub-regional programmes falling within the new focus of FSSDD; and

4. to facilitate exchange of information on programmes and relevant activities through the use of electronic databases and processed information from these databases, meetings, conferences, workshops; etc.

In view of the above, the ECA argues that S&T policy at the national, sub-regional and regional levels in Africa are needed because:

- the role of science and technology in development is still not fully appreciated by African governments;
- Africa will not develop without a much greater contribution to S&T, with a resulting greater impact of science and technology on its socio-economic development;
- Africa has a vast unrealised development potential, including a very large reservoir of unexploited resources – human and natural – and much value can be added to these resources through science and technology;
- past policies in science and technology on the continent – where they exist – have generally not been very effective in many countries in accelerating development;
- where policies exist and have been relatively effective, they still need to be reviewed substantially and continuously to face the many new and very important economic and technological changes emerging or stemming from the global situation at the turn of the 3rd millennium
- Africa is facing unique and worsening problems, particularly food insecurity and environmental unsustainability, which have not been addressed adequately by science and technology policies thus far.

4.4.3 Developing Scientific Infrastructure

A number of regional and sub-regional institutions have been established following the formative years of ECA. These institutions are called "ECA-sponsored institutions" in that the ECA was most involved in the initiatives and preparatory work for their establishment. The sub-regional institutions emerged to support development and integration efforts at the sub-regional level in such areas as trade, maritime transport and mineral resources in which the establishment of a regional institution was considered to be a more realistic approach. They also served as training centres in major fields including banking and finance, science and technology, industry, trade, natural resources, transport and communication, and economic planning and management (ECA, 1993). These regional institutions were created to support the development efforts of Africa as whole, including the promotion of a broad mass of African capabilities and capacities in strategic fields such as science and technology, engineering design and manufacturing, remote sensing, economic planning and management and social development. In fact, six of these institutions deal with various aspects of science, technology and industrial development and transformation in the African region, and are therefore related to this study. Besides those related to industrial development, there are others dealing with natural resources-related issues. The institutions whose programmes are related to S&T are listed in Table 4.11 below. Some of these institutions were not operational for some years after the official agreements were signed; in some instances it took 3 years for this to happen.

TABLE 4.11: ECA-Sponsored S&T Institutions

Name of Institution	Location	Year of Establishment
African Regional Centre for Technology	Dakar, Senegal	1980 (1977)
African Regional Centre for Engineering Design and Manufacturing (ARCEDEM)	Ibadan, Nigeria	1980 (1979)
African Regional Institute for Higher Technical Training and Research (AIHTTR)	Nairobi, Kenya	1980 (1979)
African Regional Organisation for Standardisation (ARSO)	Nairobi, Kenya	1979 (1977)
Regional Centre for Services in Surveying, Mapping and Remote Sensing (RCSSMRS)	Nairobi, Kenya	1974/75
Regional Centre for Training in Aerospace Survey (RECTAS)	Ile Ife, Nigeria	1972
Regional Institute for Population Studies (RIPS)	Accra, Ghana	1972
African Centre for Applied Research and Training in Development (ACARTSOD)	Tripoli, Libya	1981(1977)
African Regional Industrial Property Organisation (ARIPO)	Harare, Zimbabwe	1976
African Industrial Property Organisation (AIPO)	Yaounde, Cameroon	1962
African Organisation for Cartography and Remote Sensing (AOCRS)	Algiers, Algeria	1988
African Centre of Meteorological Applications for Development (ACMAD)	Niamey, Niger	1992
Regional Remote Sensing Centre (CRTO)	Ouagadougou, Burkina Faso	

* Figures in brackets represent the year in which the institution was initially created.

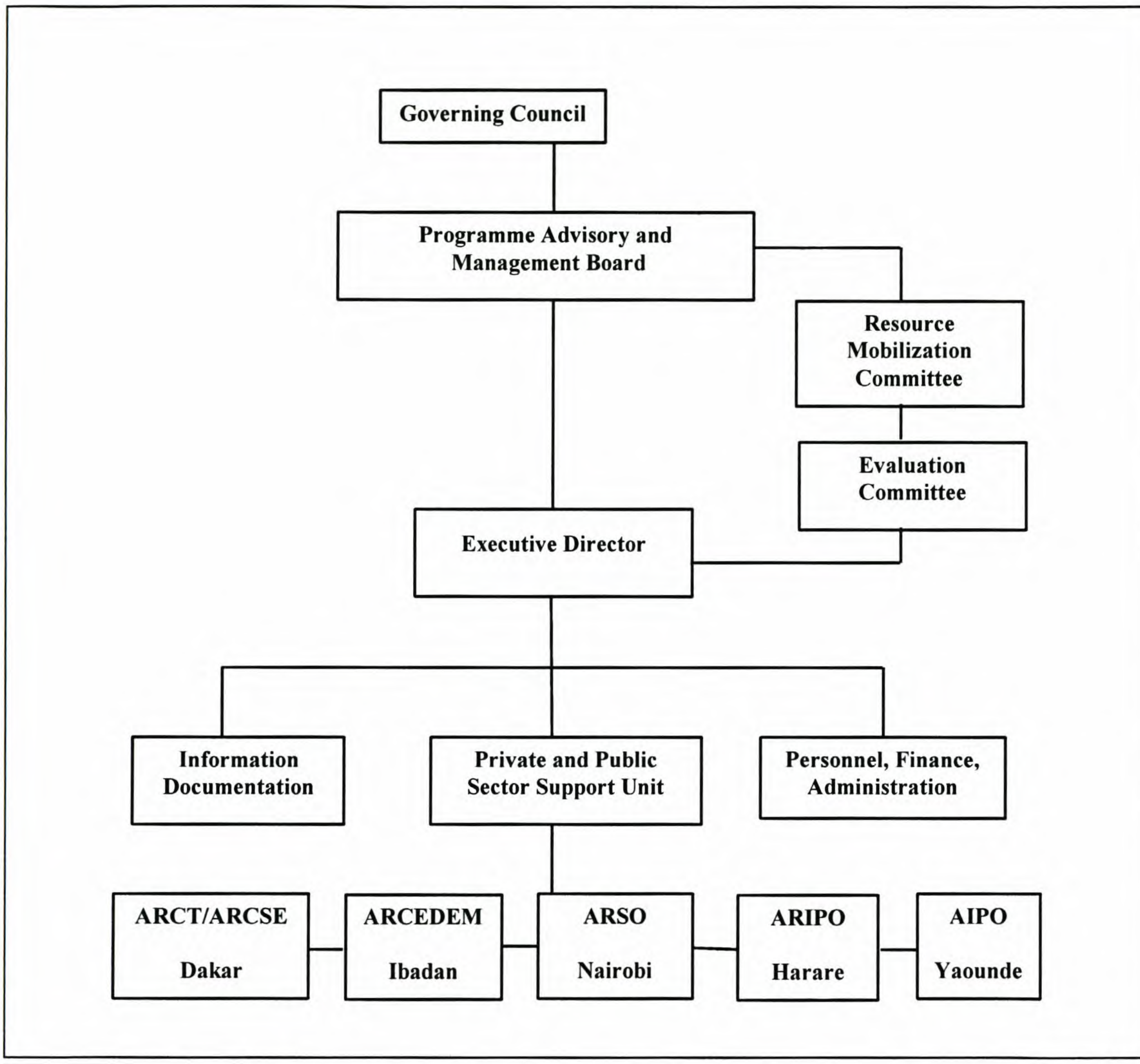
While the above institutions were basically regional in purview, the sub-regions were more linked to management, the Port Management of Eastern and Southern Africa (PMAESA) being a notable example. However, the creation of these institutions mushroomed to the extent that some of them became non-viable projects. This forced the ECA to undertake a region-wide evaluation of all the sponsored institutions in 1993. The main conclusions of the evaluation, which were published in a document entitled Rationalisation *and harmonisation of ECA-sponsored institutions*, are:

1. In the spirit of rationalisation, it is proposed that ARCT, ARCEDEM, ARSO, AIHTTR, ARIPO and AIPO should be merged as one institution to be called "Regional Organisation for Technological Transformation in Africa (ROTTA)", under single governance and management, constituted by a Governing Council with three arms as proposed earlier.

2. In the short or medium term, the various institutions can remain in their present locations as departments of the single organisation to be headed by an executive director. However, a headquarters should be designated from among the present locations in the light of the following considerations: strong industrial base; developed infrastructure including land and premises; potential for expansion; and degree of potential host country's commitment and willingness to provide additional support. For technical considerations, it would be important in the foreseeable future for all the institutions to be centralised in one place.

3. As for the African Regional Centre for Solar Energy (ARCSE), all indications are that it is extremely unlikely that it will ever become viable and sustainable in its present location. In fact, at present the Centre is virtually closed, with all operations suspended. Since the main objectives of ARCSE also fall within one of the priority areas of ARCT, merging it with it the six institutions of the industrial services group will be a prudent approach. A diagrammatic representation of the whole process is presented below. Similarly, the Regional Remote Sensing Centre (CRTO) should be merged with the African Regional Centre for Aerospace Surveys (RECTAS) (both are sub-regional bodies). However, arrangements should be made to retain the infrastructure in Ouagadougou as training branch office. Other notable sub-regional institutions in the natural resources sector are the Eastern and Southern African Mineral Resources Development Centre (ESAMRDC - Dar-es-Salaam) and the Central African Mineral Resources Development Centre (CAMRDC - Brazzaville). It is recommended that he latter two institutions be maintained as separate sub-regional bodies, but should work closely with sub-regional groupings. The proposed structure of the new institution is shown in Table 4.12 below.

TABLE 4.12: Proposed structure of merging six institutions



Source: E/ECA/CM.19/17; 1992.

However, during the session of the ECA Conference of Ministers responsible for Economic and Social Development and Planning in Africa, held from 5-8 May 1997, the ministers considered a reviewed report based on the earlier one under the rubric *Rationalisation of ECA-sponsored Institutions: Renewal for Improved Service.* This report included an assessment of the capacities of these institutions in the context of ECA's new strategic vision (direction) and its ability to enhance the Commission's impact on the selected areas of priority in which ECA is considered to have a comparative advantage (ECA, 1999:62). Following the conference discussions and recommendations, the ECA is currently redefining its relationship with these institutions based on:

1. The functionality of these institutions;

2. The relevance of their programmes to ECA's new strategic orientations; and

3. The support to these institutions from their member states.

According to the ECA (1999:62), the final objective of the above exercise is to transform these institutions and strengthen the most effective of them into regional centres of excellence. The likely institutions under consideration are: the African Regional Centre for Engineering Design and Manufacturing (ARCEDEM), the African Institute for Economic Development and Planning (IDEP), the Regional Centre for Training in Aerospace Survey (RECTAS), the African Regional Standardisation Organisation (ARSO) and the African Centre of Meteorological Applications for Development (ACMAD).

4.4.4 Evaluation

From the late 1970s the ECA adopted an approach of techno-regionalism in its development of the scientific and industrial infrastructure in Africa. Thus the six scientific and technological institutions set up by the ECA were intended to assist Africa in its industrial transformation and development. However, the reality is that since their establishment Africa's share of world industrial output has deteriorated considerably. In other words, there has been a de-industrialisation in the African continent, excluding North African countries and South Africa. Worst of all, in most of the host countries where these regional institutions have been established, we have witnessed a reduced performance of the industrial sectors of their economies in terms of the amount of value-added products.

The transformation of these institutions into a single, broad regional scientific and technological institution remains to be implemented. In fact, even though the various host countries do not effectively provide adequate financial support towards the running of the various institutions within their national borders, they nonetheless see the presence of these institutions as a source of national prestige. For instance, Nigeria and Senegal are allegedly engaged in the merger of ARCT and ARCEDEM, with each suggesting a new head office of the merged institution. In fact, Nigeria feels it has more support for the establishment of ARCEDEM than Senegal's support for ARCT.[20] Therefore, during the session of the ECA Conference of Ministers responsible for Economic and Social Development and Planning in Africa (5-8 May 1997), the ministers considered a revised report on *Rationalisation of ECA-*

[20] Interview May 2001.

sponsored Institutions: Renewal for Improved Serve. The report included an assessment of the capacities of these institutions in the context of ECA's new strategic vision (direction) and their ability to enhance the Commission's impact in the selected areas of priority in which ECA is considered to have a comparative advantage (ECA, 1999:62).

Meanwhile, at the Third Meeting of the Advisory Board on Science and Technology in October 2000, it emerged that the ECA, Nigeria and Senegal have still not been able to iron out their differences for the merger between ARCEDEM and ARCT. Therefore the ECA took a tentative decision to disengage itself from ARCT, if there is no merger, and that "ARCT will be allowed to evolve on its own" (ECA, 2001:6).

It may be argued that the rationalisation process of the ECA-sponsored institutions has coincided with the declining prospect of funding them from the voluntary resources of the UNDP to these organisations. There has meanwhile been a steady inclination towards a voluntary funding system at UNDP, making contributions uncertain, at the same time that science and technology is considered as a much-neglected area of the voluntary funding system (Desai, 1997:45). This has been evident from the steady decline of funding for science and technology in UNDP sectoral allocations during the period 1972-1992. Therefore institutions have to rely on extra-budgetary sources to finance their science and technology programmes. For example, in spite of the usefulness of the ECA programme on a Science and Technology Network (ESTNET), which is intended to improve and disseminate scientific information in Africa, it has not been implemented due to lack of funding from external donors.[21]

Besides the on-going transformation of the ECA-sponsored institutions, there is also currently a fundamental weakness within the ECA itself with regard to the promotion of S&T development in Africa, even at the policy level. For example, the FSSDD Science and Technology Team is under-staffed. Although the ECA reported to the Advisory Board on S&T in October 2000 that it was upgrading and strengthening its S&T Team, the process has been very slow. The Senior Scientific Affairs Officers had still not been appointed at the time of my field trip in May 2001. One officer at P-3 level was appointed in April 2000, but she left in early 2001.[22] Meanwhile, one officer has to do the work of four. There seems to be too

[21] The programme should have established in the year 2000, however at the time of my visit to ECA in May 2001, it has not been started.
[22] Interview with Dr Jacques Hamel, Senior Science and Technology Team leader ECA, May 2001.

much bureaucracy, complicated by the UN quota systems for the appointment of employees from different countries which seeks to address over representation from some countries, but S&T development in Africa should not suffer because of bureaucratic inertia.

Furthermore, there is no internal co-ordination and co-operation between the FSSDD Science and Technology Team and the Regional Integration and Co-operation Division, which is necessary for matters of scientific and technological co-operation to be placed on the integration and development agenda.

Unlike UNESCO and the World Bank, the ECA approach to regional infrastructure development came close to techno-regionalism, viewed as the "pursuit of scientific and technological co-operation and networking within a certain region" (Posadas, 1999:199). Neither the ECA approach to techno-regionalism nor the individual African states' approach to techno-nationalism has been, very successful so far. Besides the setting up of regional S&T institutions, at the sub-regional level the ECA set up the Multinational Programming and Operational Centres (MULPOCs) in five African regions (Eastern and Southern Africa, West Africa, Central Africa, North Africa and the Great Lakes Community) in 1977.[23] These MULPOCs are intended to help co-ordinate and implement programmes at the sub-regional levels.

It was within these MULPOCs that the ECA also set up the sub-regional Science and Technology Working groups prior to the organisation of its First African Regional Science and Technology Conference in 1995. However, these sub-regional S&T working groups also fizzled out after the conference since there were no mechanisms to institutionalised them besides the subsidiary body of African Regional Conference on Science and Technology has also been abolished. Although the expert-body on Natural Resources, Science and Technology has been established at the regional level, it is still unclear how it will link with the SRDCs both in terms of S&T programmes development and implementation.

23 Note that the MULPOCs have been renamed Sub-Regional Development Centres (SRDCs) after the completion of the restructuring process at the ECA in 1997.

4.5 GENERAL CONCLUSION

In summary, there has been a fundamental recognition of the importance of science and technology for development at various different periods since the establishment of the United Nations Education Scientific and Cultural Organisation, which has been influential to some extent in constantly drawing the attention of the international development community to this issue. The World Bank, since it started lending to developing countries after the reconstruction of post-World War II Europe, also began taking a keen interest in S&T issues in the early 1970s during the McNamara presidency; while the Economic Commission for Africa has also been involved in assisting Africa set up some S&T institutions for capacity building, as well as in the organisation of workshops, seminars and conferences, in which the other two institutions have also been participating.

An interesting finding of this chapter is that, while all the three institutions are autonomous, co-operative agreements are often negotiated among them. For example, the World Bank has concluded co-operative arrangements with UNESCO which were often used to the Bank's advantage. During the 1970 fiscal year eight of the projects which were approved were identified or prepared with the help of UNESCO. UNESCO staff members also participated in eleven Bank missions during that year for preliminary identification of education projects, before their agreement was terminated in 1986. It is now being rebuilt in a more active way.

All the three institutions argue that they support science and technology, but their levels of support differ. However, all their programme support for S&T at the regional and sub-regional level is quite limited, except the ECA which took more interest in the late 1970s and 1980s in helping to establish a number of regional and sub-regional S&T infrastructure. Extra budgetary sources have created donor dependence on the extent of funding from these institutions for programmes in Africa. The bulk of the amount supporting the World Bank's SPAAR programme does not come from the Bank itself. Besides, the use of funds for the organisation of seminars, meetings, conferences and symposia is common among all three institutions. However, after all these meetings and conferences nothing much is left for the development of scientific and technological capacity in Africa for this continent's transformation and development.

CHAPTER FIVE

SCIENTIFIC AND TECHNOLOGICAL CO-OPERATION IN AFRICA: THE ROLE OF REGIONAL INSTITUTIONS

5.1 INTRODUCTION

In the preceding chapters we dealt with the emergence and institutionalisation of scientific and technological co-operation and made mention of some of the regional institutions, which have been established, as well as their activities. In fact, in Chapter 3 we did not provide any particularly detailed analysis of the programmes of the current regional institutions as we did for the colonial period. We touched on some of the post-national efforts, which then provided us with an impetus to tackle the international institutions with a geographical purview in Africa. Of special interest were the programmes and activities of UNESCO and the lending patterns of the World Bank in support of science and technology in the developing regions, with Africa as our main focus. Unfortunately, Africa has been the recipient of the least number of Bank loans. The efforts of the ECA towards promoting scientific and technological capacity building in Africa were also analysed. Together these three institutions have not performed very well in sustaining scientific and technological infrastructure, and therefore skills development, in Africa – particularly at the regional and sub-regional levels. Chapter 4 four was mainly concerned with international institutions

The main thrust of the present chapter is to evaluate Africa's own institutions and to determine their commitment to the development of scientific and technological co-operation in Africa. There are numerous institutions in Africa, but those with the most regional outlook are the African Development Bank, in terms of development finance, and the OAU – both in terms of its geographical purview as well as in its role as the leading institution in continental co-operation and integration in various fields of human endeavour.

5.2 THE AFRICAN DEVELOPMENT BANK

5.2.1 Introduction

African States began discussing the establishment of a regional development bank at the All-African Peoples Conference which was held in Tunisia in January 1960, although at that time most of the countries were still under colonial rule. At this Conference a resolution was passed in favour of "setting up of an African investment bank to promote development projects". This idea of creating an African Development Bank (AfDB) was concretised through a unanimous resolution which was adopted by all the African countries which attended the third session conference of the United Nations Economic Commission for Africa (ECA) in February 1961. Thus the ECA's unanimous resolution was to request its executive secretary (Mr Robert Gardiner) "to undertake a thorough study of the possibility of establishing an African Development Bank and to report to the Commission at its next session" (White, 1970:92). The need for capital for economic development, the need for co-operation between the different African countries, the need to overcome some of the national and regional divisions which have marked the history of the continent and the emergence of African countries into independence were some of the motivations (Singer, 1964:209). Besides, the failure of an attempt by the UN in the late 1950s to expand its role in development financing by a means of a proposal to establish a Special United Nations Fund for Economic Development, which was deflected with the establishment of the IDA, was also a motivation. The Inter-American Development Bank (IDB), which had been opened in 1959, and the consideration of an Asian Development Bank (AsDB), set to be operational in 1966, was a further motivation. English and Mule (1996:19) note that "[t]he vision behind the establishment of the African Development Bank was clearly one of self-reliance, through co-operation among African states, as proclaimed in the preamble to its 1964 Agreement".

Often regarded as the premier African multilateral institution (English & Mule, 1996:1), the African Development Bank (AfDB) was finally established at a Conference of African Finance Ministers representing 23 states held in Khartoum, Sudan, from 16 July to 4 August 1963.[1] Technically, however, the bank formally came into existence on 10 September 1964, with the accession of Algeria as the twentieth member country, which brought the aggregate subscriptions to the required amount of US$250 million. This is because Article 65 of the agreement states that the agreement could only come into effect upon the deposit of

[1] The countries were Algeria, Burundi, Central African Republic, Egypt, Ethiopia, Ghana, Guinea, Ivory Coast, Kenya, Liberia, Libya, Mali, Mauritania, Morocco, Nigeria, Sierra Leone, Somali, Sudan, Tanzania, Tunisia, Uganda and Zaire. Then on 18 December 1963 the Agreement was further signed on behalf of the governments of the following states: Benin, Cameroon, Congo, Niger, Rwanda, Senegal, Togo and the Upper Volta by the representatives at the UN headquarters in New York, thus bringing the signatory nations of the ADB Agreement to 30 states in that year. Incidentally, the then governor of the Central Bank of Sudan, Mr Mamoum Beheiry, later became the AfDB's first President (See AFDB, 1989).

instruments of ratification or acceptance by twelve signatory governments whose subscriptions added up to not less than 65% of the authorised capital stock. The inaugural meeting of the Board of Governors (mostly Finance Ministers) was held from 4-7 November 1964 in Lagos, Nigeria, and the Bank's headquarters was opened in Abidjan, Côte d'Ivoire in March 1965. However, the AfDB started business operations on 1 July 1966, but actually signed its first loan agreement in August 1967.

Unlike the ECA, the AfDB is one of the regional financial development institutions to assist in the mobilisation of resources for the socio-economic development of the African continent. In accordance with Article 1 of the AfDB Agreement, "The purpose of the Bank shall be to contribute to the economic development and social progress of its regional members - individually and jointly". In order to perform and achieve its purpose, the AfDB was to perform the following functions:

- To use the resources at its disposal to finance investment projects and programmes which will promote the economic and social development of its regional members, giving special priority to those which concern several members, rendering their economies increasingly complementary and bringing about an orderly expansion of their foreign trade;
- To undertake to participate in the selection, the study and preparation of projects, enterprises and activities contributing to such development;
- To mobilise and increase, in Africa and outside Africa, resources for the financing of such investment projects and programmes;
- To promote investment in Africa of public and private capital in projects or programmes designed to contribute to the economic development or social progress of its regional members;
- To provide technical assistance as may be needed in Africa for the study, preparation, financing and execution of development projects and programmes; and
- To co-operate with national, sub-regional and regional development institutions in Africa, as well as to co-operate with other international organisations pursuing a similar purpose and with other institutions concerned with the development of Africa.

In the first ten years of its existence the membership of the AfDB (unlike the other regional development banks) was an all-African initiative without non-regional shareholders. That is, the membership of the bank was limited to the independent African states. Although it was not explicitly stated, a state could not become a member of the AfDB if it were not first a member of the Organisation of African Unity (OAU). But OAU member states were not necessarily obliged to become members of the AfDB (Fordwor, 1981). This kind of adjunct relationship between the AfDB and the OAU made the procedure of membership of the former similar to the relationship that had earlier existed between the World Bank and the IMF, whereby membership of the IMF was conditional on becoming a member state of the World Bank.

Nonetheless, since 30 December 1982, non-African regional membership has been introduced into the AfDB, which is similar to the system operated by the Inter-American Development Bank (IDB) at its establishment.[2] This was part of the effort aimed at increasing the capitalisation of the AfDB through the subscription of non-African members. However, attempts were made to ensure that the bank did not lose its African character in the amended Charter. Among these were the requirement to reserve two-thirds and one-third of the institution's capital shareholding respectively for African and non-African members; the presidency was restricted to African citizens only; its operations would be confined to African countries; and lastly, a mandatory requirement was that no major decision should be taken without a two-thirds majority (AfDB, 1991). At present the AfDB has 53 African and 24 non-African member countries (known as the Regional Member Countries (RMCs). Based on gross national product (GNP) per capita, the members are classified into three categories: Category A, Category B and Category C.[3]

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[2] The decision to include the non-regional members of the ADB was adopted as a formal proposal in 1977, thus taken five years before a final negotiation was reached in 1982 and the amendment of the original Agreement effected, and it required serious negotiations with the non-regional members. Some countries resisted the inclusion of non-regional members for a long time before they eventually agreed to it, due to the lack of adequate capital stock of the bank. As the AfDB noted in 1991, the non-regional members helped the bank to create a large resource base and increase its operations. The admission also enhanced the image of the bank in the international capital markets to such an extent that since 1984 the institution has enjoyed top credit rating from some of the well-established rating agencies, in both the USA and Europe (see AfDB, 1991).

[3] The Category A countries are those which qualify for ADF concessional funding only (concessional loans and for limited ADB lending for enclave and private sector projects) and this category currently numbers 38 countries. However, the group of Category A also includes Nigeria and Zimbabwe, which are at present the only two countries in Category B, and which qualify for a blend of ADB and ADF resources (concessional and non-concessional loans), while Category C countries are eligible for ADB resources only (non-concessional loans). These countries include Algeria, Botswana, Egypt, Equatorial Guinea, Gabon, Mauritius, Morocco, Namibia, Seychelles, South Africa, Swaziland and Tunisia as well as Libya, which are, however, not a Borrowing Member Country.

The statutory organs of the AfDB as identified in its charter are the Board of Governors (the supreme policy-making body), the Board of Directors (with general responsibility for the conduct of its operations), and the President (chief executive and legal representative of the AfDB).[4] The Organisation's operations divide Africa into five regions (East, Central, West North and South) and it has five Regional Departments, although it is currently experimenting with the idea of Country Offices.

5.2.2 AfDB Resources

The financial resources of the AfDB are separated into ordinary capital resources and special resources. The former are first and foremost derived from the subscriptions of its members as well as through external borrowing against callable capital and income from guarantees of loans. Funds from these sources are loaned to the African members on non-concessional terms. The latter includes the funds and income from these operations. However, on 29 November 1972 the bank established the African Development Fund (ADF) with the help of 13 non-regional state participants, which increased to 26 states in 1990 (ADB, 1991).[5] The Fund's Agreement is based on a model similar to that of the International Development Association (IDA) affiliate of the World Bank and therefore loans from the Fund are made with a repayment period of fifty years and a service charge of 0.75% per annum (Mingst, 1990). However, since IDA reduced its repayment period of loans to 40 years, with a grace period of 10 years, and a service charge of 0.7%, the ADF lending is also based on the same terms.

In 1976 the AfDB's resources were further augmented with the signing of an Agreement between it and the Federal Republic of Nigeria establishing the Nigerian Trust Fund (NTF), with initial subscription of 50 million naira (N50 million which was then US$51 million), to provide concessionary loans to the less well endowed African countries.[6] Towards this end,

[4] The former governor of the Central Bank of Sudan at the time of the AfDB establishment, Mr Mamoum Beheiry, became the AfDB's first President (See AFDB, 1989).
[5] With an initial sum of US$82.6 million, increased to UA 272 million in 1976-78 (ADF-I), the Fund has been replenished eight times and total resources made available the African countries stood at UA 11.13 billion between 1974 and 2000. The replenishment increased by an average of 43% up to ADF-V (1976-90). This peaked at ADF-VI (1991-93), when with UA 2.441 billion it was 8.4 percent higher than the previous replenishments. However, this was followed by a drastic drop of 47 percent in the level of replenishment for ADF-VII, a protracted negotiation, before it rose again over the ADF-VIII period in 1999-2001(ADB, 2001). Negotiations are underway for replenishment for ADF-IX.
[6] The equivalent was US$ N50, 000,000 in 1976.

the NTF funds are loaned to states on terms intermediate between the AfDB and the ADF conditions. Thus, in line with Article VI of NTF Agreement, NTF loans have an interest rate of 4 percent; a repayment period of 15- 25 years, including a five-year grace period; and a commitment fee of 0.75% per annum (for details, see original agreement). Two other special funds are part of the economic resources of the AfDB group, the Arab Oil Fund and the Special Relief Fund, which are designed specifically to help drought-stricken African countries. Hence the AfDB Group lending comprises both concessional and non-concessional loans (Mingst, 1990; English & Mule, 1996).

5.2.3 AfDB Policies and Programmes

Singer (1964), one of the early supporters of the idea of African Development Bank, argued that from the beginning the AfDB could focus its attention on seven different types of projects, which it should undertake:

- Regional projects;
- Promotion of inter-African trade;
- Promotion of exchange economies;
- Fulfilling the needs of newly independent countries;
- Education and training;
- Promotion of small-scale African industrial enterprise;
- Development plans: long-range.

According to Singer (1964:211), the need for regional projects in Africa arose (and still arises) from the fact that individual African countries are often too small to be viable economic units for any balanced economic planning. Moreover, the national boundaries are often in the nature of administrative borders rather than boundaries defining economic units. The arguments raised are still valid today. For example, some of the regional projects which needed to be established were health and locust control, higher education and technological research, transport projects, large-scale industries, irrigation projects, river-valley development schemes and migratory-labour links. Emphasis on regional projects will call for the formulation of general principles as to how the political and economic problems arising could be tackled (Singer, 1964:211).

While still in line with its stated mission, the new Vision Paper of the AfDB commits it to an overarching goal of poverty reduction around which operations focus on:

- Three sectoral themes: agriculture and rural development, human resources development and private sector development;
- Two sectoral themes: good governance and economic integration and co-operation; and
- Two-cross-cutting issues: gender and the environment (AfDB, 1999).

5.2.4 AfDB Educational Finance

The AfDB started its financial support to African educational systems in 1975, when it granted its first support to an education project in Mali. A review of the total lending of the AfDB Group revealed that between 1975 and 1998 the bank committed a total amount of US$2.4 billion, made up of 176 loans and grants, in support of a number of education projects and programmes in Africa. During this period education lending accounted for 67 percent of total social sector lending, which represented an average of about 10 percent of the total AfDB lending. In terms of the various Windows of the AfDB Group, 5.3% of the total AfDB lending and 17.7% of ADF total lending was devoted to the social sector (AfDB, 1999:5).

The study also shows that, during the 1975-84 period, a total amount of US$388.8 million was disbursed for 41 education loans and grants. This disbursement accounted for 59 percent of social sector lending for the same period. However, there was significant progress during the period 1985-1998, when education financing accounted for an average of 70 percent of all the social sector lending. Similarly, the number of education loans and grants also witnessed a significant rise to 135 between 1985 and 1999, with an estimated total value of US$2.0 billion (AfDB, 1999:5).

According to the breakdown into programmes and projects of the bank, the AfDB's funding went in support of construction, rehabilitation, equipment and furnishing of all kinds (academic and vocational/technical) encompassing primary, secondary and tertiary levels of education. The support also includes training of teachers, school heads and inspectors, curriculum designers and educational planners. Provision of institutional support and technical assistance has also been important. Most of the bank's education projects have been at the national level. A number of important regional projects have, however, also received

AfDB support. In addition, the bank has supported multi-sectoral projects where there have been important training and human resource development components (AfDB, 1999:5).

Furthermore, an analysis of the bank lending in support of the education sector reveals two main trends. First and foremost, between 1975 and 1990 priority was given to secondary-level education including general and vocational education, technical and teacher training. This level of education accounted for 48.8 percent of the total value of all education projects financed between 1985 and 1990. Secondly, during the period 1991-1998, in contrast, 52.8 percent of the total lending to education went to basic education, of which 39.7 percent went to the primary level and 13.1 percent to non-formal education. Meanwhile during the same period secondary and higher education programmes accounted for 38.4 and 8.7 percent of education lending. However, this shift over the years towards basic education has been interpreted as falling in line with the recommendations of the bank's 1986 Education Sector Policy Paper (ESPP) and the 1990 Jomtien Conference on Basic Education for All (AfDB, 1999:5).

5.2.5 AfDB Multilateral Lending

While there are many ways in which the bank can and does promote regional integration, the most visible has been the financing of multinational projects that are jointly undertaken by two or more countries or by a regional institution. These investments include industrial and agricultural lines of credit to sub-regional development banks, namely: the East African Development Bank (EADB) based in Kampala, Uganda; the Bank for West African Development (BOAD) based in Lome, Togo, which supports development initiatives in Francophone West Africa; the Development Bank of the Great Lakes States (BDEGL) located in Goma, Democratic Republic of the Congo, which supports development initiatives in that region; and a direct credit to ECOWAS in 1988 to help finance a 3-year industrial development programme (AfDB, 2000).

According to Gardner and Pickett (1984:104), between the period 1964 and 1984 the area in which the AfDB is said to have made the most significant contributions to is Technical Assistance (TA) loans in the financing of engineering studies. According to them, the AfDB Group has granted various loans in the engineering field, the first being a loan of US$70,000 granted to the Government of Uganda to cover the foreign exchange component of engineering studies of an urban water supply and sewerage scheme. Then from 1977 to 1984 the AfDB Group financed an average of about three studies per year. However, grants and financial aid to development and research-oriented institutions such as the Onchocerciasis Fund, International Livestock Centre for Africa (ILCA) and the Tropical Disease Fund were modest. In fact, by 1980 only a total amount of US$968,692 had been distributed by the AfDB Group to support these programmes (Gardner and Pickett, 1984:104). It therefore comes as no surprise when, under the Lagos Plan of Action, the AfDB was tasked in the spirit of African Declaration on Co-operation, Development and Economic Independence to "devote at least half of its programme resources to multinational projects, and assign a definite percentage of these resources to financing S&T projects during the period 1980 to 2000" (OAU, 1980:69).

However, to date, the largest loans awarded by the bank have been to the West African Development Bank in 1987 (US$54 million); Air Afrique in 1990 (US$53 million);[7] and the Muela Hydropower project, benefiting Lesotho and South Africa, in 1992 (US$54 million) (English & Mule, 1996:150). The AfDB also identifies a second category of projects, which are national but serve to increase complementarity among countries, such as ports or roads improving access to a border. However, English and Mule (19996) argue that the regional benefit of these projects is sometimes difficult to assess and not always the main reason for the investment. Overall it has been estimated that a 2.3 percent share of AfDB Group lending over the period 1969-1989 was to multinational projects (English & Mule, 1996:150).

In spite of this the AfDB Group has attached a high priority to multinational projects, to the extent of stipulating in its 1982-86 Operational programme that 10 percent of its resources would be channelled in this direction. In practice, however, it has proven impossible to honour these intentions. Lending of this type for 1982-86 amounted to only UA 4126 million, or 2.4 percent of its total commitment. Equally disconcerting is the fact that the share of multinational projects dropped to the point where they accounted for less than 1.0 percent of total lending in 1991-1993. In 1993 the bank was essentially confined to the supporting of feasibility studies. It has also stopped setting lending targets in this area (English & Mule, 1996:150). Similarly, a study by the ECA (1993:19) concluded that "over the years, AfDB has built a strong reputation as a highly successful development finance institution, attracting membership beyond the African continent. While the AfDB has accomplished a great deal in terms of assistance to national development efforts, support to regional development

[7] Eleven Francophone countries in West and Central Africa own Air Afrique.

initiatives through sub-regional and regional institutions, however, has not been as impressive. However, the Bank has been nursing the idea of developing and supporting 'centres of excellence' to spearhead development in certain strategic sectors".

In fact the AfDB (2000), in its own assessment of the Group's contribution to regional co-operation and integration through its support for funding multinational projects in its new *Economic Co-operation and Regional Integration Policy Paper*, came to the following conclusion:

> ... physical infrastructure projects, especially those in the transport sector, have performed well. Performance of lines of credit has, however, been mixed and points to the need to be more selective in the choice of national development banks as lending institutions. In the industrial sector, the CIMAO project, due to high production costs, has experienced severe capacity under-utilisation and lacked market competitiveness.

Realising the past weaknesses of its education sector policy, particularly in promoting integration and co-operation in Africa, the AfDB notes that its lending will be guided by five main principles, one of which is that it is "convinced that regional integration provides regional member countries with the best opportunities to face the challenge of globalisation. Therefore, increased efforts will be made to promote greater regional and subregional co-operation, through financing multinational institutions (i.e. centres of excellence) especially in higher education and scientific research and education systems management. Information technologies (i.e. distance and open learning, the Internet, etc.) offer powerful tools that could facilitate regional co-operation in education development (especially at the secondary and tertiary levels)" (AfDB, 1999:20). At the consultations meeting on the replenishment of the ADF held in Valencia, Spain from 31 May to 1 June 2001, the bank presented a proposal for a strategic framework for ADF-IX. The proposal also reiterated its call for multinational programmes and projects and noted:

> The development efforts of African countries would also need to be formulated increasingly in the framework of regional co-operation and integration efforts. Apart from their traditional roles, regional integration and co-operation schemes in Africa are important vehicles for integration into the world economy, as well as providing a powerful impulse for research acceleration of economic growth in the region. Despite some important gains, the overall record of regional integration schemes in Africa falls short of the ambitious targets that had been set for them ... These should focus on joint investments and exploitation of natural resources, regional policy harmonisation, institutional capacity building, and the development of an integrated regional infrastructure and financial markets. In addition to the mobilisation of their own resources, these interventions will require additional financial resources; co-operation and collaboration with Africa's development partners (AfDB, 2001:3).

Perhaps the only notable examples of AfDB support for regional and subregional S&T programmes are the support for the Agricultural Research Management Training (ARMT) programme which is executed by SCCAR with the help of the Eastern and Southern African Management Institute. Since 1999 SACCAR has secured US$250, 000 funding over a three-year period from the AfDB for ARMT phase III, which is due to end in July 2002 (SACCAR, 2001:11). ARMT aims at improving the performance of National Agricultural Research Systems (NARS) within SADC through the strengthening of capacity and by the training of research managers in planning, organising and managing research. This is to help increase their efficiency and effectiveness in addressing the food problems of member states. One of the research areas which the AfDB funds also supports through SACCAR is a limited funding for the Southern Africa Bean Research Network for research and strengthening of leadership in Research Management (SACCAR, 2001:17). Another grant of AfDB support has gone to the Algeria-based African Agency of Biotechnology, a continental Agency for the promotion of biotechnology in Africa.

5.2.6 Evaluation

The concept of regional integration and co-operation has commanded a very high priority among African leaders since the late 1950s. This has led to the creation of a variety of regional co-operation organisations (i.e. over 200 organisations have been established to promote regional co-operation in Africa). The Agreement establishing the African Development Bank is one example of such an important step forward that was taken. However, since it began lending in 1967 the AfDB lending for projects and programmes has remained predominantly national. Some critics of the AfDB argue that the World Bank has realised that the AfDB may be an important legitimating institution for the international development community in Africa (Mingst, 1990:128). For example, a kind of "trilateral approach" exists between the AfDB WB and IMF. The International financial community ties its own aid to the establishment of IMF and World Bank adjustment programmes in borrowing countries.

Although the issue area of the AfDB was (and still remains) securing the control of development resources meant for African states; the link with the Bretton Woods twins means that in terms of policy directions and programmes; the institution's support has been compromised.

The AfDB provides some financial support to the West African Rice Development Association (WARDA). WARDA is "an autonomous intergovernmental research association with a mission to strengthen Sub-Saharan Africa's capability for technology generation, technology transfer and policy formulation, in order to increase the sustainable productivity of rice-based cropping systems while conserving the natural resource base and contributing to the food security of poor rural and urban households".[8] However, it is not known how much assistance it has offered since WARDA was formed in 1971. Table 5.1 indicates the financial approval of the various programme areas into which AfDB support has gone between 1967-2000.

Table 5.2 below shows the AfDB Group's total cumulative lending in loans and grants between 1967-2000 to various regional member countries expressed in sub-regional terms by sectors and percentages. Thus the AfDB Group started operations in Central Africa in 1972. Since then the Group has approved 407 loans and grants valued at UA 3.6 billion to the region. Secondly, the AfDB Group began operations in East Africa in 1967, with the first loan to Kenya. The cumulative approved loans and grants cover 468 projects and are worth UA3.92 billion. Thirdly, the AfDB Group began operations in North Africa with a loan to Tunisia in 1968. Since then the Group has approved 324 loans worth UA 9.17 billion for the sub-region. The cumulative AfDB Group lending in loans and grants to Southern Africa amounted to UA 4.04 billion, which covers 425 loans and grants. Of this number, 283 included only operations for the ADF-only eligible countries, which represents 60.7% of the lending, which amounts to UA2, 45 billion. Lastly, the West African sub-region has been the highest recipient of AfDB Group loans and grants. Up to the 2000 fiscal year, the AfDB Group approved 677 loans and grants, which were worth UA 6.87 billion. Thus 369 approvals of the loans and grants, which represents 45.3 percent, went to CFA countries, whilst UA3.76 billion i.e. 54.6% went to non-CFA countries. Furthermore, the sectoral breakdown shows that the agricultural sector received most of the AfDB disbursement within the period of study. However, Table 5.2 does not show any details of the programmes supported under the broad sectors which are multinational and will promote S&T development and co-operation within the sub-regions. In any case, as the educational analysis reveals, AfDB Group assistance has gone mainly into basic education, with a limited amount to the tertiary level of education, where the prospects for co-operation are much higher.

8 http://www.cgiar.org/warda)

TABLE 5.1: Summary of AfDB and AfDB Group operations 1967-2000

Year	1995	1996	1997	1998	1999	2000	1967 - 2000	No.
Total Approvals		353.40	591.81	667.97	789.64	843.49	18062.42	832
Loan & Grant Approval by Sector		353.40	572.02	590.27	768.87	407.85	17378.90	809
Agriculture and Rural Development		27.35	25.07	--	10.53	31.72	2483.39	142
Transport		60.41	67.81	22.74	153.36	36.72	2584.65	157
Communication		--	24.89	79.03	--	--	594.99	42
Water Supply and Sanitation		--	--	49.74	19.60	67.40	1287.10	68
Power Supply		--	65.47	145.02	46.82	--	2119.56	84
Industry, Mining and Quarrying		12.16	14.33	48.11	0.70	3.79	1648.39	83
Finance		100.00	214.85	50.00	356.75	182.72	32559.77	137
Education		--	19.81	30.00	--	79.87	799.00	31
Health		2.09	8.36	0.36	0.72	1.89	107.75	21
Multisector		151.39	131.43	165.28	198.03	3.74	2470.01	42
Other Approvals*	**0.00**	**0.00**	**19.79**	**77.70**	**20.77**	**435.64**	**683.52**	**23**
AfDB Group								
Total Approvals		**572.30**	**1393.40**	**1243.59**	**1287.06**	***1984.08***	**29534.00**	**2470**
Loan & Grant Approval by Sector		**558.54**	**1317.25**	**1165.89**	**1195.21**	**1070.04**	**28114.28**	**2416**
Agriculture and Rural Development		27.45	137.11	139.07	137.43	175.05	5420.14	624
Transport		110.34	181.13	65.05	208.28	156.34	4572.19	429
Communication		--	24.89	79.03	--	--	741.53	71
Water Supply and Sanitation		40.95	39.83	58.47	45.31	100.07	2072.21	222
Power Supply		34.65	66.99	156.16	51.67	38.53	2706.37	162
Industry, Mining and Quarrying		12.16	42.33	48.11	0.70	4.61	1858.12	124
Finance		105.00	214.85	50.00	378.75	192.30	3600.84	191
Education		12.00	113.81	150.70	54.92	109.42	1891.89	177
Health		9.80	63.57	60.82	45.69	72.07	951.03	158
Multisector		159.19	384.98	307.26	233.28	174.59	4049.51	205
Other Approvals		13.76	76.16	77.70	91.85	914.04	1419.72	54

Source: African Development Bank *Compendium of Statistics 1999.*

Another study indicates that during the period 1962-1995 the IDB provided support for S&T, higher education, training and agricultural research which totalled US$3.8 billion. Of this amount, US$1.4 billion went in support of 31 operations defined as science and technology projects in which the total project size (loan and counterpart) is estimated at US$2.6 billion, while a new set of loans totalling US$350 million was approved for Argentina, Guatemala, Uruguay, Panama, Venezuela and Chile for the period 1998-2000. Again support for higher education amounted to US$0.7 billion, US$0.7 billion for technical education and job training, US$1 billion for agricultural research and extension services (IDB, 2000:10). Furthermore, IDB support for research and extension in the agricultural sector also covered major assistance for international co-operation in agricultural R&D to over fifteen research centres in areas such as potatoes, wheat and maize. This included over US$180 million to agricultural research through non-reimbursable technical co-operation operations and now through a Regional Fund for Agricultural Technology, which will ensure the sustainability of these activities (IDB, 2000).

A new strategy for IDB S&T operations for promoting and sustaining the creation of knowledge for development within the IDB's operational purview is shown in Table 5.4 below. The policy is based on a systems approach to ensure economic and social progress and to make the region part of the global knowledge economy. Other main elements of the strategy are "an increased emphasis on technology; continued support of science research and training with increased emphasis on critical areas; increased support to smaller, poorer countries; and a parallel increase in support for education and training which will affect S&T capacity in the region directly and indirectly" (IDB, 2000:15).

TABLE 5.4: A Summary of the New IDB Science and Technology Strategy for LAC

S&T PROBLEMS IN COUNTRIES OF LAC	OBJECTIVES	TYPICAL TOOLS
I. SYSTEMS APPROACH		
Absence or weakness of national innovations systems (NIS)	**Co-ordinate public policy and create incentives for system-wide collaboration among NIS stakeholders**	• Stakeholder dialogues • Policy studies and identification of key linkages • Loan conditionalities and requirements
II. INCREASED EMPHASIS ON TECHNOLOGY		
Imbalances between S&T supply and demand	**Ensure a closer matching of S&T supply and demand**	• Technology development funds for enterprises • Support for joint R&D projects and exchange of personnel between universities and users • Linkage requirements in funds that support supply • Public sector procurement and regulatory policies
Low productivity due to lack of technological diffusion	**Promote the dissemination of existing technologies which are appropriate for the conditions of each country**	• Support for S&T services, especially those of information and extension • Adaptation of foreign technologies • Development of sectoral technological centres • Middle-level technical training and professional up-dating
Little competitiveness due to insufficient technological innovation	**Encourage firms to engage in Research and Development (R&D)**	• Technology development funds for enterprises • Risk or venture capital funds • Fiscal incentives • Intellectual property rights
III. CONTINUED SUPPORT OF SCIENCE RESEARCH WITH GREATER CONCENTRATION IN CRITICAL AREAS		
Scarce capacity for high-quality research Dispersion of capacity and little linkage between R&D and development needs	**Escalate and refocus national research efforts, with more effective use of resources**	• Funds for peer review based competitions of research projects • Block grants and discretionary project financing in some cases • Selective strengthening of institutional infrastructure
IV. PROACTIVE SUPPORT TO SMALLER, POORER COUNTRIES		
Concentration of S&T progress in a few countries	**Greater support to smaller, poorer countries**	• Technical co-operation to identify critical needs and develop specific national and sub-regional strategies • Assistance in stakeholders dialogues • Financing of comprehensive national programmes of S&T
Little collaboration among countries of the region	**More international co-operation in S&T**	• Regional technical co-operation projects • Support for co-operation among countries through components of national programmes
V. PARALLEL INCREASE IN SUPPORT FOR EDUCATION AND TRAINING		
Weak base of qualified human resources	**Remedy shortages of qualified human resources and strengthen the base of education and training**	• Funds for high-level training of human resources • Strengthening of research and postgraduate programmes in universities • Middle-level technical training and professional up-dating • Programmes to improve mathematics and science teaching at the elementary and secondary levels

Source: Adapted from IDB, 2000.

The IDB example shows that the AfDB may not necessarily require an S&T policy before it can start to support S&T capacity building in Africa, but it is very appropriate to have one in order to prevent any approach without clear-cut objectives. Even internally there is no Unit within the AfDB which handles S&T issues. The bank is now establishing an engineering team to enable it to carry out its monitoring and evaluation task successfully.

5.2.7 Conclusion

In summary, the African Development Bank, even though is said to be the foremost multilateral development institution in Africa, has failed to adequately support scientific and technological capability building. For example, in the area of scientific infrastructure very little is known about the Bank Group support. While the critical mass of scientific and technological skills remains a major problem, the Group's emphasis on basic education means that African countries have to rely on the magnanimity of the developed world for the training of high-level skills. This lack of support for scientific and technical institutions, especially at the tertiary level, is similar to the World Bank's approach to the funding of S&T in Africa. Besides, the increasing response of the Bank to policy-based lending arguably confirms the concerns raised by some scholars and commentators that it is only implementing the policies of the Bretton Woods sister institutions. Since the World Bank is not financing scientific research infrastructure in Africa, AfDB cannot do so, because it is increasingly dependent on the co-financing of most of its programmes. In spite of the AfDB Group's inability to adequately support regional and sub-regional programmes and projects in the past, African leaders still have the hope that it will change its policies to help mobilise the necessary resources in support of such programmes. For example, the *New Partnership for Africa's Development* expects the AfDB to play a meaningful role in the promoting of public-private partnership capacity building and to help mobilise sustainable financing for the programmes. This is, however, a major challenge to AfDB Group.

5.3 THE ORGANISATION OF AFRICAN UNITY

5.3.1 Introduction

The Organisation of African Unity (OAU), which we briefly touched on in our discussion of the history and institutionalisation of science and scientific co-operation in Africa in Chapter 3 of this study, is the first multilateral institution that was established by independent African states at the continental level in Africa after World War II. The OAU and the African

Development Bank are the two leading multilateral institutions in Africa with a clear mandate to promote regional co-operation and integration in Africa, besides the United Nations Economic Commission for Africa. This is by no means an easy task, particularly when it comes to the promotion of scientific and technological co-operation for the development and transformation of the continent of Africa. Clearly, during its establishment in May 1963, the new Organisation did not lose sight of such demands and therefore scientific and technological development and co-operation became one of the main aims in its Charter. That is, Sub-section 2 of *Article II* of the OAU Charter stresses co-operation, thereby emphasising that member states shall co-ordinate and harmonise their general policies especially in the following fields:

- Political and diplomatic co-operation;
- Economic co-operation, including transport and communications;
- Educational and cultural co-operation;
- Health, sanitation and nutritional co-operation;
- Scientific and technical co-operation; and
- Co-operation for defence security.

Within the current structure of the OAU, scientific and technological co-operation falls under the Department of Community Affairs, formerly the Department of Education, Science, Culture and Social Affairs (ESCAS). This includes the Scientific, Technical and Research Council (STRC), which is an Executive Secretariat, as we mentioned in Chapter 3, based in Lagos, Nigeria. Four other specialised sub-regional offices were also established to help the OAU promote and co-ordinate the application of S&T for development in Africa:

- The Inter-African-Bureau for Animal Resources (IBAR) in Nairobi, Kenya;[11]
- The Scientific Secretariat of the Inter-African Phytosanitary Council (IAPSC) in Yaounde, Cameroon;
- The Co-ordination Office of the Semi-Arid Food Grain Research and Development projects (SAFGRAD) in Ouagadougou, Burkina Faso;

[11] This office was established as the Inter-African Bureau of Epizootic Diseases (IBED) in 1951. Its mandate was extended in 1956 to include other conditions, such as ill health of a psychological, nutritional and genetic origin, hence it became known as the Inter-African Bureau of Animal Health (IBAH). Then in March 1970 the name of the Office was changed to IBAR.

- The Co-ordination Office of the Project on the Integrated Development of the Fouta-Djallon Highlands in Conakry and Labe in Guinea.

The first two were established during the colonial period as inter-territorial co-operation institutions. They were retained after independence, though the original names have been changed over time (see Chapter 3).

5.3.2 OAU/AU Policies and Programmes

The first substantive policy of the OAU for promoting S&T co-operation was initiated at the Algiers meeting on Science and Technology in February 1964, which recommended the establishment of a Scientific, Technical and Research Commission (STRC) of the OAU and defined its main functions. The recommendations and functions of the STRC were later approved by the Assembly of Heads of State and Government in Cairo in 1964. The functions of the STRC are:

- To deal with all scientific and technical matters related to the general development of member states;
- To promote training and exchange of technical and research manpower;
- To promote scientific policies for adoption by member states and execute at their request joint programmes on scientific and technical research;
- To promote the effective utilisation of research findings with a view to accelerating socio-economic development of Member States;
- To seek and obtain external funding for OAU projects of common interest to member states sponsored by the OAU in the field of science and technology;
- To seek facilities for disseminating information to researchers in the field of science and technology in Africa;
- To undertake scientific evaluation studies of the natural resources of the continent.

This development was intended to anchor the institutionalisation of a body responsible for scientific endeavour within the OAU. However, nothing concrete happened until after the United Nations Conference on Science and Technology for Development held at Vienna, Austria, in 1979. Following this Conference, with the help of the ECA, the OAU formulated the Lagos Plan of Action for the Monrovia Strategy for the Economic Development of Africa

(OAU, 1980). The LPA duly included a chapter on science and technology which, according to Boneachenhou (1982), presents the first attempt at formulating a comprehensive science plan for Africa within the framework of a strategy for economic development. This strategy included the creation, by the end of the century, of an African Economic Community, collective self-reliance and control of foreign actors (see Eisemon *et al.,* 1985:200).

The LPA had barely been implemented (it was no more than half-way through the implementation process) when, with a renewed sense of regionalism and increasing trends towards scientific and technological co-operation emanating from a desire to participate in Big Science, African leaders showed a keen interest in formulating another regional co-operation agreement, hence the Abuja Treaty was signed. In view of the effective regional co-operation, as envisioned in the Abuja Treaty of 1991 for the establishment of an African Economic Community by 2025, various policy protocols, including that of science and technology, were needed to foster regional and sub-regional co-operation.

Thus, building on the 1980 LPA, which was in the process of being implemented, Articles 48-60 of the Abuja Treaty deal with issues relating to science and technology for development. However, Articles 51-53 specifically deal with S&T. Article 51, subsection 1, states that member states shall:

- strengthen scientific and technological capabilities in order to bring about the socio-economic transformation required to improve the quality of life of their population, particularly that of the rural populations;
- ensure the proper application of science and technology to the development of agriculture, transport and communications, industry, health and hygiene, energy, education and manpower and the conservation of the environment;
- reduce their dependence and promote their individual and collective technological self-reliance;
- co-operate in the development, acquisition and dissemination of appropriate technologies; and
- strengthen existing scientific research institutions and, where they do not exist, establish new institutions.

To achieve these objectives within the context of regional and sub-regional co-operation, subsection II of Article 51 notes that member states of the OAU shall:

- harmonise, at the Community level, their national policies on scientific and technological research, with a view to facilitating their integration into the national economic and social development plans;
- co-ordinate their programmes in applied research, research for development and scientific and technological services;
- harmonise their national technological development plans by placing special emphasis on local technologies, as well as their regulations on industrial property and transfer of technology;
- co-ordinate their positions on all scientific and technical questions forming the subject of international negotiations;
- carry out a permanent exchange of information and documentation and establish community data networks and data banks;
- develop joint programmes for training scientific and technological cadres, including the training and further training of skilled manpower;
- promote exchanges of researchers and specialists among member states in order to make full use of the technical skills available within the Community; and
- revise the educational systems in order to better adapt educational, scientific and technical training to the specific developmental needs of the African environment.

Furthermore, *Article 52* calls for the taking of necessary measures in order to prepare, as well as implement, joint scientific and technological development programmes. This could be achieved through the formulation of a science and technology Protocol in line with *Article 53,* which was to be annexed to the main Treaty after it had been formulated.

However, initial attempts to set in motion a process to have a draft Protocol on Science and Technology discussed and ratified failed (Nel & Teng-Zeng, 1999). As the above initiatives have not been very successful, it should be noted that the OAU is to be transformed into the African Union in July 2002, following the launching of the Transition of African Union in

July 2001.[12] However, some of the S&T structures are supposed to be maintained as the Constitutive Act of the African Union (AU), *Article III (m),* makes provision to "advance the development of the continent by promoting research in all fields, in particular in science and technology" (OAU, 2000), as one of the main objectives. It further tasks the Executive Council to promote S&T and calls for the establishment of Specialised Technical Committees, one of which will be on S&T (see the Constitutive Act of the African Union for details).

Alongside the AU, there is another working document: *The Millennium Africa Recovery Programme* (called the MAP Initiative or the New African Initiative) stressing the idea of the African Renaissance. The MAP Initiative and the Constitutive Act of the AU also recognise the significance of scientific and technological development and co-operation in Africa and outlines the actions needed to make the 21st century a success story for Africa.

Thus the Millennium Africa Recovery Programme (MAP) Final Report, as submitted to the 37th Heads of State and Government meeting at the Zambian Capital, Lusaka, calls for the establishment of science and technology Platforms in Africa (MAP is now known as the New Partnership for Africa's Development – NEPAD*)*. Their main objectives are:

- To promote cross-border co-operation and connectivity by utilising knowledge currently available in existing centres of excellence in the continent;
- To develop and adapt information collection and analysis capacity to support productive activities, as well as for export outside Africa;
- To generate a critical mass of technology expertise in targeted areas that offer high growth potential, especially in biotechnology and geoscience;
- To assimilate and adapt existing technologies in order to diversify manufacturing production.

To achieve the above set objectives, NEPAD calls for the following actions:

- Establish regional co-operation on product standards development and dissemination, and on geographic information systems (GISs);

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[12] The Republic of South Africa will be hosting the formal launching of the Summit in July 2002. The Transitional Secretary-General of the AU is the former Foreign Minister of Ivory Coast, Mr Amara Essy.

- Develop networks among existing centres of excellence, especially through the Internet, for cross-border staff exchanges and training programmes, and develop schemes to assist displaced African scientists and researchers;
- Work with UNESCO, the Food and Agricultural Organisation (FAO) and other international organisations to harness biotechnology in order to develop the commercial potential of Africa's rich biodiversity and indigenous knowledge base by improving agricultural productivity and developing pharmaceutical production;
- Expand geoscience research to enhance the exploitation of the mineral riches of Africa;
- Establish and develop a skills-base in product engineering and quality control to support diversification in manufacturing.

Towards this end it can be argued that, since 1980, there had been S&T policy documents (even if they had not been very comprehensive) to serve as a guide for African governments to work with individually and collectively. In this connection, what programmes has the OAU been able to implement, from an institutional point of view, to transform African economies towards development and competitiveness? The OAU scientific policies are executed with the help of technical expert committee systems, which assist the STRC.[13]

5.3.3 The AFRA Programme

One of the programmes of the OAU is the African Regional Co-operative Agreement for research, development and training related to nuclear science and technology (AFRA). This was an inter-governmental agreement, signed to promote the development and application of nuclear science and technology in Africa on 4 April 1994. The agreement came into being as a result of some African countries requesting the International Atomic Energy Agency (IAEA) to help them establish regional co-operation in Nuclear Science and Technology in Africa, similar to arrangements in Asia and Latin America (OAU, 1999:3). The aims of AFRA is therefore to facilitate:

[13] The most active of these committees are: Inter-African Committee on Maps and Survey; Inter-African Committee on Soil Science; Inter-African Committee on Agriculture and Mechanisation of Agriculture; Inter-African Committee on Oceanography and Fisheries; Inter-African Committee on Fertilisers; Inter-African Committee on Medical Plants and African Pharmacopoeia; Inter-African Committee on Solar Energy, New and Renewable Energies; and Inter-African Committee on Forestry.

- technical co-operation among developing countries (TCDC);
- a greater sharing of resources, including facilities, equipment and expertise;
- a greater pooling of knowledge and closer communication and collaboration between scientists and technologists in Africa;
- building on the achievements attained through national efforts and previous IAEA assistance.

5.3.4 The Pan African Rinderpest Campaign

The creation of the Inter-African Bureau for Animal Diseases in the 1950s was due to the devastating effect of rinderpest on animal health and reproduction and therefore on the sustainability of livestock production in Africa. The mandate of dealing with Epizootic diseases falls within the OAU's sub-regional office, IBAR, based in Nairobi, Kenya.[14] After the Africanisation of IBAR in the second half of the 1960s, the OAU launched the Pan-African Rinderpest control programme, which ran between 1970 and 1976, with the aim of eradicating rinderpest in Africa. However, this programme was not successful and an outbreak of the disease in the early 1980s led to the relaunching of a major programme from 1986-1990 covering the most seriously affected areas (Burkina Faso, Ethiopia, Mali, Nigeria and Sudan) in the initial stages (OAU/IBAR, 1998).

The main objectives of the programme are to:

- to control and finally eradicate rinderpest from the African continent through vaccination campaigns, systematic epidemiological surveillance and active investigation of outbreaks and control of animal movement whenever possible;
- to restructure livestock services in order to make them more economically self-sustaining, and help revitalise the livestock sector as a whole, while providing for appropriate improvements of husbandry methods to prevent desertification.

[14] The main objectives of IBAR are: a) co-ordinate activities of all OAU member states in the field of animal health and production; b) collect, collate and disseminate information in all animal health and production; c) initiate, develop and execute projects in the field of animal health and production; d) liaise with appropriate authorities of member states, regional groups, inter-governmental and international organisations.

The PARC programme, which covers thirty-four countries in Africa, led to the establishment of five vaccine production banks to allow for an immediate action in Africa in the areas worst affected by rinderpest. The United Nations Food and Agricultural Organisation (FAO), which implemented a component on epidemiosurveillance, had two TA's setting up a network of more than 25 national laboratories, as well as vaccine quality control (PANVAC in Debre-Zeit, Ethiopia, with two TA's (OUA/IBAR, 1998:10). In fact, rinderpest still remains one of the major hindrances to animal health, and therefore to the production of animals and animal products for export into the international market. Although some positive progress towards the eradication of the disease has been made, with a reduction from twenty affected countries in the 1980s to four in 1991, only twelve countries in the affected areas (Côte d'Ivoire, Egypt Gambia, Ghana, Guinea, Mali, Mauritania, Niger, Senegal, Tanzania and Togo), have so far been able to notify the Paris-based International Organisation of Epizootics (OIE) Pathway of their 'Provisional Declaration of Freedom from Rinderpest', (OUA/IBAR, 1998:11-12). This remains so, because of periodic outbreaks of the disease in the other affected countries.

5.3.5 The SAFGRAD Programme

Besides the Pan-African Rinderpest Campaign, the Semi-Arid Food Grain Research and Development (SAFGRAD) is one of the longest running programmes.[15] The recurrence of severe drought in semi-arid Africa between 1968 and 1973 led to major crop failures that caused malnutrition, starvation and famine. This prompted the launch of the SAGRAD programme in 1977 by the African Heads of State, after a resolution was passed in 1976 by the OAU Council of Ministers meeting in Mauritius (OAU, 1995:4). The mandate of SAFGRAD was to co-ordinate all food grain and farming system research and development in the semi-arid areas of Africa. Thus, between 1979 and 1993, the programme developed the skills and expertise of about 2,534 scientists from Africa through the offer of scholarships for MSc and PhD training, participating in conferences and developing research skills, among others. These developments are tabulated below. The breakdown of these achievements in terms of research capacity-building include:

- long-term training of 30 scientists, from nine SAFGRAD member countries, at MSc and PhD levels

[15] It is this programme which led to the establishment of the OAU sub-regional S&T Office in Burkina Faso.

- 350 scientists and technicians from 26 SAFGRAD member countries benefiting from short term resident research training courses, which lasted from 3 to 12 months, to improve the research skills of the awardees,
- 40 scientists from 20 countries benefiting from short-term training of about 2 weeks, aimed at improving their research and technology transfer skills
- 165 scientists from 26 countries participated in scientific monitoring tours. Visits and discussions were held in the field and in laboratories, which enabled them not only to become acquainted with research methodologies and production constraints, but also served the purpose of fostering collaborative working relationships with scientists from the various countries that they visited, as well as with others who also participated in the monitoring tours.

Furthermore, 295 African scientists from all SAFGRAD member countries, as well as other countries, participated in scientific conferences organised by SAFGRAD; while 1664 scientists participated in SAFGRAD workshops and seminars (OAU/STRC-SAFGRAD, 1995:5-6).

5.3.6 Financial Resources

The financial resources of the OAU are derived from the member states' contributions and voluntary contributions from other donors from the international development community including both bilateral and multilateral sources. However, the non-payment of member states contributions remains one of the thorny areas in the running of the OAU, which is rather a major problem. For instance, at of the end of financial year ending 31 May 2001, a total amount of US$12,972,845.07 was received as an assessed contribution that represents only 47% of the expected contribution of US$27,600,000.00. During the 2000/2001 fiscal year, a total number of 15 countries of the Organisation's 53 member countries were able to make full payments of their financial commitments. These countries are: Algeria, Angola, Botswana, Chad, Equatorial Guinea, Ethiopia, Lesotho, Mauritius, Mozambique, Namibia, Senegal, South Africa, Swaziland, Toga, and Zambia. Furthermore, seven of these countries made a prepayment totalling US$667,586.40 towards the budget for 2001/2002. These are Botswana, Equatorial Guinea, Lesotho, Mozambique, Senegal, Togo and Zambia. Meanwhile, as at June 2001, fourteen countries of the OAU have fallen under sanctions due to default in payment of their contribution under Article 115 of the financial rules and regulations (Salem, OAU, 2001).

The non-payment of assessed contributions of member states to the OAU means that the Organisation has to constantly rely on extra-budgetary sources, just like the other institutions, which we have mentioned in the previous sections. For example, the Pan-African Rinderpest Campaign programme was launched only in July 1986, following the signing of a financial agreement between the OAU General-Secretary and Officials of the European Union in Addis Ababa, Ethiopia. The EU granted a total amount of 57.7 million ECU to support the programme's first 4 years from 1986-1990. This was funded from the EU's Lomé III regional funds (OAU/IBAR, 1998:8). Then, under Lomé IV in 1994/95, another agreement was signed between the OAU and the EU, with a total budget 48.5 million ECU for the financing of eleven national programmes as well as support for the OAU/IBAR. This support was augmented by funds from bilateral and multilateral sources from other developed countries (OAU/IBAR, 1998).

5.3.7 Evaluation

The creation of appropriate scientific infrastructure is critical to the promotion and sustainability of scientific research programmes. In the case of the PARC programme, a regional epidemiology unit was established in Nairobi, Kenya in 1986, with the assistance of the UN Food and Agricultural Organisation (FAO). This unit has been responsible for the improvement of rinderpest detection and diagnosis, the development of simple diagnostic kits and training materials, handling of vaccines and establishment of data collection and processing. However, the activities of the unit were severely restricted due to the lack of adequate funds from 1991 until 1996, when a new funding agreement was signed for another three years (1998:13). Similarly, regional projects provided a communications expert to the OAU/IBAR PARC office in Nairobi (19989-1992) and another one in Bamako (1990-1991). These programmes, however, were terminated and only revitalised after the signing of a Technical Assistance agreement between the OAU, European Commission and FAO.

The ineffectiveness of STRC in promoting scientific collaboration has already been emphasised by Odhiambo (1991), who notes that the STRC (based in Lagos), which was to assist in the implementation process, was little known outside a small circle of dedicated specialists and governmental planners in Africa, as it lacked presence and credibility. Its advice rarely drew attention and therefore it ceased to be an effective inter-governmental organ for technical co-operation in Africa. The Scientific Council of Africa (SCA), which replaced the CSA as the science advisory body, was similarly unknown and during the whole of the 1980s it met only twice. Odhiambo (1993:89) further writes:

> "the operational agenda of the OAU has been- during the first three decades of its existence- an overwhelmingly political one: on decolonisation, abolition of apartheid, resettlement of refugees, resolution of interstate conflicts, etc. This circumstance is understandable, as it is of historical import. Of the 925 resolutions passed by the OAU Council of Ministers over 20-year period 1963-82, a mere 3% dealt with solidly scientific and technological issues (and probably 12.5% with associated scientific and technological matters). With the lack of science-led development in Africa so glaring in present technology-dominated world, it is important that equal attention to research and development (R&D) as an engine of socio-economic development be paid by the OAU, its organs, and other regional and national development entities".

Still the SCA, which is the main expert advisory body to the STRC, meets bi-annually. The current acting Executive Secretary of the STRC, Dr Adeniji Kolawole supports this trend, emphasising that this brings about effectiveness and efficiency and addresses pressing issues confronting the continent in the field of S&T.[16] Meanwhile the present structure of the Scientific and Technical Offices is ineffective and, therefore, the recommendation for their restructuring, in line with the general evaluation of the OAU, is a welcome idea.

At the OAU headquarters itself, two main programmes are run: Firstly, the awarding of a Gold Medal to the best African inventor in every two-year period. This is a way of encouraging scientists and researchers to come up with solutions to African problems using local materials in Africa. However, the OAU has no plan to help in the commercialisation of such inventions. The second programme implemented from the OAU headquarters is the nuclear science and technology programme, aimed particularly towards the eradication of tsetse fly, which affects animal production. According to Dr Atef Ghabrial, a pilot project which was run on the island of Zanzibar in the Republic of Tanzania, using nuclear technology, has proved very successful. Following that, an area-wide programme has been launched through the AFRA initiative, which promotes co-operation. As Ghabrial puts it, "there is no passport control for tsetse flies" - hence co-operation among countries in the affected areas is needed for any possibility of effective eradication.[17]

[16] Discussion in May 2001.
[17] Interview with Atef Ghabrial, OAU Senior Science and Technology Policy Advisor, OAU, May 2001

One of the main weaknesses of the OAU programmes is they are all dependent on external donor support, whether bilateral or multilateral, for funding. For example, under SAFGRAD, the United States Agency for International Development (USAID) has contributed substantially to promote the programme. Between 1979 and 1993, the agency contributed US$33,764,000 out of the US$45,261,145 total. The OAU, contributing $842,000, and the AfDB, with $803,023, also provided support between 1989 and 1994. On the other hand the contributions from Member States in-kind amounted to US$3,070,900 between 1986 and 1991 (OAU/STRC, 1995:12).

Similarly, both the Pan-African Rinderpest Campaign programme and the African Regional Co-operative Agreement for research, development and training related to nuclear science and technology (AFRA) are supported by the European Union and the International Atomic Energy Agency respectively. This means that the OAU as an Organisation, and also its sub-regional Offices of S&T, do support any programme of regional interest, with 50% of funding coming from them. In fact the main mission of IBAR, which is the technical arm of OAU dealing with livestock development in Africa, is to raise and solicit funding to formulate programmes of regional interest and implement them in collaboration with the beneficiary countries in African.[18] Therefore, no matter how successful such programmes are, they cannot be labelled regional co-operation and attributed solely to regional institutions. Instead, international co-operation is more appropriate here, since multilateral and bilateral donors provided the human resource capacity building and research expenditure.

The transformation of the OAU into the African Union also poses problems in the science and technology sector. In the Organisation, there is no clear direction in the form S&T co-operation. Some of the personnel in the sub-regional S&T Offices have been asked to reapply for their positions, while there is an advertisement for the position of an Executive Secretary in Lagos. Unless there is an improved infrastructure in information and communication technologies at the various sub-offices linking the OAU Secretariat, effective co-ordination of their activities is not possible. Furthermore, the current structure of the OAU Secretariat downgrades science and technology, since the Secretariat is not in a position to handle continental programmes.

[18] Interview with Dr H. Solomon, Acting Director of OAU/IBAR, Nairobi, May 2001.

At the policy level, the formulation of a Protocol on Science and Technology, in line with the Abuja Treaty of 1991, failed because the STRC Office in Lagos believes that the 1980 Lagos Plan of Action (LPA) chapter on Science and Technology is still relevant.[19] As the STRC acting Executive Secretary noted, the Abuja Treaty's call for an S&T policy only compliments LPA efforts. Surprisingly, the African Academy of Science (AAS) which should be capable of providing input for policy formulation at the regional level, also believes it is still working on the LPA provisions. This indicates that those who are in responsible positions and supposed to spearhead the policy formulation and implementation process, are often not using the correct, current, regional documents or promoting and facilitating their implementation. Furthermore, the OAU has an agreement with UNESCO but the Secretariat is not up to date with UNESCO's policy proposal for debt relief for Science and Technology development within the Heavily Indebted Poor Countries Initiative. The two need to co-ordinate their position, since the majority of the LDCs are in Africa and most of them heavily indebted to both bilateral and multilateral financial institutions including the World Bank and the IMF.

The only area where the OAU has been able to formulate a regional policy that could have a greater impact is its "Model Legislation on the Protection of the Rights of Local Communities, Farmers and Breeders and for the regulation of Access to Biological Resources". In July 1998, the OAU Heads of State endorsed the Model Legislation and recommended that it become the basis of all national laws on the matter across Africa. However, this Law has received strong opposition from the World Intellectual Property Organisation (WIPO) and the Union for the Protection of New Plant Varieties (UPOV) both claiming the law requires fundamental review because, in its current form, it does not protect plant breeders' rights, among others.[20] Besides the OAU/STRC is sponsoring the African Pharmacopoeia project which is aimed at promoting the development of African traditional knowledge and medicine, it does not however, have the appropriate infrastructure in place and only runs two pilot programmes.

[19] The African Economic Community Draft Protocol on Science and Technology was drafted and revised in 1993, but lacks any details and priority setting. Therefore it was never annexed to the 1991 Abuja Treaty, as required.
[20] "IPR Agents Try to Derail OAU Progress" GRAIN, 19 June 2001.

5.4 GENERAL CONCLUSION

Together, the African Development Bank and OAU are the leading multilateral institutions with continental purview in Africa, created by African countries. The Charters establishing both institutions give great importance to regional co-operation and integration for development and transformation. The two institutions do not operate in isolation, they have signed a number of agreements between themselves as well as with other international development institutions. The AfDB, for example, signed a co-operative agreement with UNESCO in 1968 to help in project identification, preparation of joint operations and financing of projects. The AfDB also signed a co-operative agreement with the World Bank in 1967. This agreement made provision for technical co-operation, exchange of information, conduct of joint missions, co-financing of projects, harmonisation of operational procedures and methods and the training of AfDB staff. Subsequent to this agreement, the World Bank has offered a number of training opportunities to the bank's staff in both Washington and Abidjan and co-financed a good number of projects with the AfDB Group (Gardiner and Pickett, 1984:105). For instance, under ADF III, 5 percent of ADF resources were to be devoted to technical assistance and the bank itself decided to increase its loan allocation for engineering studies (Gardiner and Pickett, 1984:110), during the bank's operational programme for the 1982-1986 period.

Similarly, the OAU signed a number of agreements with the World Bank, UNESCO and other international organisations. Given the low levels of effective co-operation among them, it is not certain how useful these arrangements have been, except in the attending of seminars, conferences and workshops. At the end of all these, no resources are forthcoming for any long-term programmes.

The establishment of the Joint OAU/ECA/AfDB Secretariat as part of the joint efforts at promoting the realisation of the African Economic Community under the Abuja Treaty of 1991, marks a further practical approach to regional co-operation and integration in Africa. However, both the AfDB and the OAU are not strong when it comes S&T infrastructure development, particularly at the regional and subregional levels. The AfDB lacks any policy on science and technology. Its educational lending supports for skills development is restricted mostly to basic education. But, increasingly, it has become clear that the human resources requirements of Africa go further than basic education. High-level skills in S&T are required to help fight hunger, poverty and disease. The future success of the *New Partnership* *for Africa's Development* (NEPAD) will to a large extent depend on how useful the AfDB Group and OAU (AU) will facilitate the mobilisation of both human and material resources in to building the needed scientific and technological capacity for sustainable development and transformation of the African continent.

CHAPTER SIX

SUB-REGIONAL INSTITUTIONAL MECHANISMS FOR CO-OPERATION IN SCIENCE AND TECHNOLOGY IN AFRICA

6.1 INTRODUCTION

In Chapters 4 and 5 we focused our analysis on international and regional institutions and their efforts at fostering scientific and technological co-operation in Africa through various programmes. The main focus in the present chapter is on the sub-regional levels of analysis. There are currently quite a number of sub-regional institutions in Africa. For example, the Treaty establishing the African Economic Community identifies five of them. However, within sub-Saharan Africa the most well established sub-regional organisations with presence and visibility in terms of programmes and geographical purview are the Southern African Development Community (SADC) and the Economic Community of West African States (ECOWAS). Therefore these two institutions and their programmes, particularly in S&T development and co-operation, are discussed below.

6.2 THE SOUTHERN AFRICAN DEVELOPMENT COMMUNITY

6.2.1 Introduction

The idea of a Southern African Development Community (SADC - pronounced *saddek*) was formally initiated at a conference in Arusha, Tanzania in July 1979. However, it was officially launched on 1 April 1980 in Lusaka, Zambia. SADC was formerly known as the Southern African Development Co-ordination Conference (SADCC) but its name was changed to SADC in August 1992 at its twelfth annual meeting in Windhoek, Namibia. The early SADCC was called upon to consider ways in which the Frontline States near apartheid South Africa could reduce their economic dependence upon her.[1] Therefore, unlike a number of African regional and sub-regional organisations whose formation was the result of sometimes rather vague general aspirations such as closer "unity", SADCC (SADC) was

[1] Beside this objective, three other main objectives were to implement programmes with national and regional impact; to mobilise member states' resources in the quest for collective self-reliance; and to secure international understanding and support (see SADC, 2001).

established in response to a precise challenge, i.e. the "pervasive and political influence of South Africa in the region" (Arnold, 1994:55). This was in spite of the fact that Malawi, as one of the original nine founding countries, had established diplomatic relations with apartheid South Africa. This notwithstanding, "(A)ll nine were fundamentally opposed to South Africa's policies" (Arnold, 1994:55). Most of the nine countries, e.g. Angola, Botswana, Lesotho, Mozambique, Swaziland, Zambia and Zimbabwe, had suffered greatly from past destabilisation tactics by South Africa, including periodic military incursions into their territories.

SADC originally had nine member countries, including Angola, Botswana, Lesotho, Malawi, Mozambique, Swaziland, Tanzania, Zambia and Zimbabwe. However, the gaining of independence by Namibia and the release of the former South African President, Nelson Mandela, who was a leading member of the African National Congress (ANC), from prison in 1990 were to change the political landscape not only in South Africa but in the whole Southern African region. This development added new impetus and direction to regional co-operation and integration. Namibia later joined SADCC, following her independence in 1990, and South Africa, the former "political foe", also joined the new SADC in 1994 in the wake of her all-inclusive non-racial election and the formation of new government. The Island states of Mauritius and Seychelles, and the Democratic Republic of the Congo (DRC) joined in 1997, thus bringing the current membership of SADC to 14 countries.

The main controlling bodies of SADC are the Annual Summit Conference (usually held in a different member country each year); the Council of Ministers; and the Secretariat, which is located at Gaborone, Botswana. (For the aims and objectives of the organisation see the SADC Treaty of 1992.)

One of the main features of the SADC structure is the allocation to member states of sectoral responsibilities for study and co-ordination of particular policies. These allocations are indicated in Table 6.1 below. However, of the fourteen SADC member countries, the Democratic Republic of the Congo (DRC) and Seychelles have not yet been allocated any sectoral responsibility and they have therefore been excluded in Table 6.1.

TABLE 6.1: Current sectoral responsibilities for individual SADC member states

Country	Sectoral Responsibility
Angola	Energy
Botswana	Agricultural Research; Livestock Production and Animal Disease Control
Lesotho	Water Resources; Environment and Land Management
Malawi	Inland Fisheries; Forestry and Wildlife
Mauritius	Tourism
Mozambique	Culture, Information and Sport; Transport and Communications
Namibia	Marine Fisheries and Resources
South Africa	Finance and Investment; Health
Swaziland	Human resources Development
Tanzania	Industry and Trade
Zambia	Employment and Labour; Mining
Zimbabwe	Crop Production, Food, Agriculture and Natural Resources

However, a study was commissioned in February 2000 to review the current sectoral responsibilities with a view to the rationalisation of the SADC institutions through the centralisation at the Secretariat of all the sector co-ordinating units (SCUs).[2] According to SADC (2001), the restructuring exercise was necessitated by the number of difficulties and constraints encountered in the process of trying to change the organisation from its former status as a co-ordinating conference into a Community.[3] An Extra-Ordinary Summit adopted a final report on the restructuring on 9 March 2001 in Windhoek, Namibia. A Department of Strategic Planning, Gender and Development and Policy Harmonisation has now been established at the Secretariat. This new Department will have four main Directorates

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[2] The Review Committee comprised a troika plus: Mozambique (then Chair of SADC), Namibia (then Deputy Chair), South Africa (Outgoing Chair) and Zimbabwe (then Chair of the Organ on Politics, Defence and Security).

[3] These difficulties include the following. Firstly, there were inadequate institutional reforms to enable the effective transformation from SADCC (Co-ordinating Conference) to SADC (the Community); resource provision and the management system were also not adequately addressed. Secondly, there was a need to put in place appropriate mechanisms capable of translating the high degree of political commitment to shape the scope and scale of community building through regional integration. This implies delegating authority and strengthening the capacity for decision-making to the relevant agencies responsible for implementing the SADC agenda. Thirdly, there was a lack of synergy between the objectives and strategies of the Treaty on one hand and the existing SADC Programme of Action (SPA) and the institutional framework on the other. Fourthly, there was limited capacity to mobilise significant levels of the region's own resources for the implementation of its Programme. Lastly, the SADC Programme of Action was financially over-dependent, to the tune of more than 80 percent, on external funding which sustained the Programme (see SADC, 2001).

conforming to the four core areas of integration as part of the restructuring process. These proposed Directorates include:

- Trade, Finance, Industry and Investment;
- Infrastructure and Services;
- Food, Agriculture and Natural Resources (FANR); and
- Social and Human Development and Special Programmes (SADC, 2001).[4]

It is under the above four Directorates that the current 20-odd sectors will be clustered. Four directors are to be appointed to occupy these positions before the end of 2002. They will then work in conjunction with the Executive Secretary and his/her deputy and other departments at the Secretariat in making the SADC more effective and efficient as a community builder. The Secretariat is the principal executive institution of SADC and it is responsible for strategic planning, co-ordination and management of SADC Programmes.

6.2.2 The History of Scientific and Technological Co-operation in the SADC Region

We have already mentioned in Chapter 3 of this study that the idea of scientific technological co-operation in the SADC region was first initiated under the Rome Declaration on Research and Development in the Region. The agreement formulated research strategies for the sub-region. These included the establishment of institutional infrastructure for promoting and co-ordinating research, and documentation as well as information exchange. The establishment of SACCAR in 1984 marks the first practical approach to regional programmes (see details below). Then, following the First African Ministerial Conference on Environment held in Cairo, 1985, the SADC countries decided to establish a regional gene bank for crops, a National Plant Genetic Resources Committee which would oversee the setting up of a National Plant Genetic Resources Centre in 1986 (Tiffin and Osotimehin (1992:99). This early initiative was followed by a comprehensive review of the regional and national S&T capacities to map strategies for regional co-operation. This study, which was commissioned and conducted under the team leadership of KE Mshigeni (the remaining members of the team being T Duncan, HAM Dzinotyiweyi, CA Martin and AR Zikonda), was completed in 1994. In this study the SADC member states expressed their belief that S&T co-operation be

[4] For more details on the restructuring report and the functions of the various directorates, see SADC Report on the Review of Operations of SADC Institutions, March 2001.

concentrated on applied aspects of S&T and R&D. It was also recommended that the focus should be on practical, project-based initiatives to improve the use of technology in the main productive sectors and on the provision of technologies for social and community needs. The task of implementing such initiatives would provide SADC with the necessary experience of S&T issues and then enable it to establish long-term arrangements for S&T co-operation (SADC, 1994:10). The study also identified four categories of mechanisms for co-operation, which called for or covered the establishment or upgrading of facilities, collaboration initiatives and networks, small-scale co-operation mechanisms and opportunities in other sectors. To enhance these activities the study recommended that:

> SADC should assist in promoting S&T co-operation in the region by establishing an S&T Co-ordinating Unit within its Secretariat at the earliest possible date. This Unit should take cognisance of other co-operation efforts and initiatives within the region.
>
> An Advisory Group of experts should be established to assist the Co-ordinating Unit in the setting of priorities and inter-sectoral linkages within the SADC region, the launching of the proposed co-operation mechanisms, the promotion of S&T issues, and the development of longer-term institutional arrangements for S&T co-operation
>
> In view of the importance of S&T co-operation to regional development, SADC should eventually establish a distinct S&T sector under its Programme of Action.
>
> S&T co-operation should, initially, be introduced on a pilot basis. Due to the constraints discussed in the Report, the Unit should start on a modest scale, make effective use of existing institutions and encourage the emergence of national S&T policies and institutions.
>
> Due emphasis should be placed on providing trained human resources, together with increasing the level of R&D necessary for supporting those sectors which remain the main contributors of foreign exchange earnings, viz.: the mining sector, and the production of biomass in all its forms (animals, vegetables, marine and microbial).
>
> Prior to the implementation of the Co-operation Mechanisms outlined in table 1, detailed project write-ups and feasibility studies (including costing), should be undertaken (SADC, 1994:10).

However, none of the above issues has been implemented and a more recent approach to sub-regional co-operation came up in the form of the *Southern African S&T Exchange Programme*, a proposal developed by the Commonwealth Science Council (CSC) in 1997. This was based upon a request to the CSC by both the government of South Africa and the Economic Commission for Africa (ECA) for the development of a programme that could lead to the exchange of S&T experts, researchers and teachers in Southern Africa (Abiodun, 1998:40). It is envisioned that the beneficiaries, who include Lesotho, Mozambique, Swaziland and Tanzania, will be able to take advantage of their nearness to South Africa with "its well established institutions, to improve their S&T infrastructure and enhance their human capacity". One of the programme's core objectives is the creation of self-reliance among these countries (Abiodun, 1998:40). Despite these efforts, S&T within SADC still remains one of the areas of controversy, where no sector seems willing to claim responsibility.

In spite of these efforts and studies there was (and still is) no Unit at the SADC Secretariat responsible for S&T co-operation and co-ordination, except for SACCAR. For example, at a sub-regional conference in 1999 it was argued that science and technology within the context of the SADC falls under the umbrella of the Human Resource Development (HRD) Sector (DACST, 1999). Although vital in the socio-economic development of the region, science and technology is said to have received very little attention from the Sector (DACST, 1999:1). On the contrary, in fact, Ms L Mavimbela, a senior Programme Officer at the SADC Human Resource Development Sector noted, "Science and Technology was not part of the responsibility of the HRD Sector". This lack of proper attention to S&T at the SADC level led to a meeting of the Directors-General/Heads of Science and Technology in the SADC region in April 1999 in Pretoria, South Africa.[5] The objectives of the meeting were:

- to develop a common understanding of the value S&T have for the region;
- to develop a process by which S&T policy issues of mutual interest could be discussed and policy initiatives be prioritised and jointly undertaken;
- to build human resource capacity for R&D in the region.

The meeting was, furthermore, to facilitate the development of a position paper for the region towards the UNESCO's World Conference on Science, which was held at Budapest, Hungary, from 29 June to 1 July 1999 (DACST, 1999:1). Thus the meeting stressed on the importance of both international and regional S&T co-operation and recommended the creation of a technical sub-committee on S&T with national focal points within SADC. Among the specific fields of research identified by the meeting include Water, Energy, HIVE/AIDS, Food security, Drought management, Trans-boundary pollution, Monitoring

[5] Nine SADC member countries were represented at the meeting including Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia and Zimbabwe. UNESCO also had a representative as well as some individual experts on S&T issues.

the movement of skills, Audit of indigenous knowledge systems, and research foresight within the sub-region (see DACST, 1999:13-18).

Over the years SADC has developed a number of protocols and projects which aim at fostering co-operation in science and technology both within Southern Africa and with the aid of their external development partners. Some of these projects and protocols include the Southern African Centre for Co-operation in Agricultural Research and Training (SACCAR), the Southern Africa Power Pool, the Protocol on Education and Training, the Water Sectoral Protocol, etc. Two of these programmes and protocols are discussed below.

6.2.3 SACCAR and Agricultural Research and Training

Co-ordinated by Botswana, the Southern African Centre for Co-operation in Agricultural Research and Training (SACCAR) was founded as a Commission of SADCC in late 1984, following the signing of a Memorandum of Understanding by the then nine members states of the Southern African Development and Co-ordinating Conference (SADCC). However, SACCAR became a fully constituted SADCC Unit and legal entity in the 1986/87 operational year (SACCAR, 1987:8).[6] The Centre, which was established with the help of donor funding, was an attempt to address the agricultural development needs of the SADCC area and also a recognition of the crucial importance of the agricultural sector as a principal employer and means of subsistence for most of the people in the region. It was also recognised that regional co-operation could benefit most by combining the region's agricultural research capacities to address the region's priority areas of agricultural research and technology development (Gakale, 1999). SACCAR was therefore the only one of the three SADC regional bodies which was partially funded centrally from the contributions of all member states.

The governance of SACCAR is vested in its Board. The membership of the Board was reconstituted in 1986/87 after the Consultative Technical Committee/Agricultural Research (CTC/AR), which had responsibility for conducting the affairs of the Agricultural Research and Training sub-sector, and for SACCAR, was abolished. The membership of the Board includes the Directors of Agricultural Research or equivalent from Member States, three

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[6] The first Interim Director was Professor Howard Steppler, appointed in late 1984. He was succeeded by its first substantive Director, Dr Martin Kyomo, in August 1985.

Deans of Faculties of Agriculture and Veterinary Medicine, two members representing the extension services (Crops and Livestock) and the Food, Agriculture and Natural Resources (FANR) Desk Officer. The main function of the Board is to review, appraise and approve the work programme and budget of SACCAR developed by the Director, and recommend to the same Ministers of Food, Agriculture and Natural Resources (FANR) to whom the Board reports on all matters pertaining to agricultural research in the SADC region. The SACCAR Board meets twice a year to review progress reports from the managers and Secretariat and tender advice on any policy or technical issues related to the projects.

Since its establishment, the mandate, strategies and activities of SACCAR have evolved considerably due to scientific, economic and political influences both within and outside the SADC region. For example, the mandate of SACCAR expanded from an initial focus on regional research on food crops to other commodities including cash crops and livestock, and regional manpower and training resources in agricultural research (SACCAR, 1987:8). It also included regional higher-level manpower and professional training in agriculture in 1987. At the same time, in February 1987 at an annual meeting with the co-operating partners a decision was taken to increase the responsibilities of SACCAR for manpower training to cover all seven sectors within the Food, Agriculture and Natural Resources Sector. Such a mandate was to widen to include research on cash crops (SACCAR, 1987). As a result further regional programmes were initiated for land and water management, in-service training in research management, agroforestry, crop and forestry germplasm collection and conservation, a maize improvement network and the utilisation of sorghum and millet for food and beverages. To co-ordinate training activities, SACCAR established the Dean's Committee, which serves as the sub-committee of the Board responsible for training matters at the tertiary level (Gakale, 1999).

SACCAR is one of the three sub-regional co-operation institutions in agricultural research and development in Sub-Saharan Africa (SSA), (the other two are the Association for Strengthening Agricultural Research in Eastern and Central Africa "ASARECA (1994)", Conférence des responsible de recherche agronomique en Afrique de l'Ouest et du Centre 'CORAF' (1985)). These sub-regional organisations have worked closely with the World Bank through its Special Programme for African Agricultural Research (SPAAR) and other International Agricultural Research Centres in Africa and other parts of the world. This, it is felt, has led to the strengthening of some of the NARS in sub-Saharan Africa. This in turn has led to increasing co-operation among the different NARSs and subsequent creation or enhancement of the activities of a number of sub-regional institutions. However, SACCAR is unique because of its linkage with SADC, the main political organisation within Southern Africa. Therefore activities of SACCAR are centred on three main areas that include Research Co-ordination, Training and Information Exchange.

From October 1998, under the pressure of funding constraints, it was transferred to the Ministry of Agriculture of the Botswana government. There is evidence that, like other regional co-operative ventures, SACCAR was jeopardised by the failure of some states to pay their dues. It now has the status of a Sector Co-ordinating Unit and is funded by the Botswana government to the amount of R1 million per annum. This change in status led to staff movement out of SACCAR, since salaries were reduced to local levels. Donors provide another US$0.74 m that covers regional capacity development programmes (DACST, 2000). Two donor-funded expatriate members of staff from France and Norway provide technical support to SACCAR.

The mandate of SACCAR, which cuts across food, agriculture and natural resources, is now focused on technology promotion and dissemination, research promotion and co-ordination and information networking, strengthening training and organising regional postgraduate programmes at centres of excellence. The German government, through Deutsche Gesellschaft fur Technische Zusammernarbeit (GTZ) scholarship awards, supports four of these centres of specialisation. Thus SACCAR is widely regarded as a model of successful co-operation in SADC and Africa in general. The major projects include the Plant Genetic Resources Centre (USD 5.8 million) (DACST, 2000:34).

As a region where agricultural science research and training dominated colonial research, the Southern African region has established regional capacity building in agriculture. In recognition of the fact that technical training and research are specialised, and that regional co-operation could yield significant economies of scale, regional institution building was given early impetus under the old SADCC. This was to avoid duplication of higher-level training in agricultural sciences and to meet the region's human resource development needs. SADCC agreed to specialise in postgraduate training at selected universities. Each of these Centres of specialisation refers to "an institution in the SADC region involved in training and research for the FANR sector, which through some agreed mechanism, is designed to provide training in a prescribed discipline to interested and qualifying students from the entire region.

It entails concentrating resources from or for the region at that institution instead of thinly spreading them over several institutions across the region" (SACCAR, 1997:16). *Centre of Specialisation* is the preferred term, because *Centre of Excellence* may connote superiority of the designated institutions over others offering training in the same discipline. The following institutions are now considered as regional centres of specialisation as shown in Table 6.2 below:

TABLE 6.2: Regional centres of specialisation in the SADC region

Name of Institution	Field of Specialisation	Location and Inception of Programme
University of Botswana	Applied Microbiology	Gaborone, Botswana
Bunda College of Agriculture, University of Malawi	Animal Sciences: animal breeding, animal nutrition and animal production	Lilongwe, Malawi; 1989/90
University of Pretoria	Food Science and technology	Pretoria, South Africa
Sokoine University of Agriculture	Land and Water Management: Irrigation and Land Use Planning	Morogoro, Tanzania; 1990/91
University of Zambia	Agronomy (Crop Science): Crop Production, Plant Breeding and Plant Protection	Lusaka, Zambia; 1988/89
University of Zimbabwe	Agricultural Economists	Harare, Zimbabwe, 1994/95

The admission of South Africa into SADC, given South Africa's scientific capability, led to the establishment of another programme at the University of Pretoria. Besides this, a new MSc Programme in Tropical Animal Health and Food Safety, involving all the universities (except Bunda College) engaged in the SACCAR training programme, has been established. The Eduardo Mondlane University in Maputo, Mozambique, is also part of the new initiative.

It is worth noting that, prior to the designation of a programme as regional and the selection of institution(s), certain criteria should be met. Thus, before a training programme can be considered to become a regional programme, the following criteria will be taken into consideration:

- Relevance of subject area to the SADC region;
- Relative importance of the subject area;
- Subject area should be identified as a priority area in the blueprint or its later annexes;
- Subject area should be highly specialised.

On the other hand, for an institution to be selected as a host for a regional training programme, the following criteria will apply:

- The willingness and commitment from the host university and government to host and support the programme;
- Present potential to be a host institution include quality of staff, number of staff, adequacy of resources and leadership in subject area;
- Record of performance in a number of areas, including research and teaching in the subject area and implementing similar initiatives, focusing on key activities, and responding to challenges;
- Acceptability among other institutions (the political element – whether it would create discontent among other universities, location and communication).
- Ability to attract and utilise financial and political support, both locally and internationally;
- Cost effectiveness in relation to the sustainability and adequacy of current infrastructure such as student and staff accommodation, laboratory space, teaching resources, library and field facilities, etc. as well as the suitability of staff and of curriculum; and lastly
- Regional balancing, i.e. does the institution already have other regional training programmes and can the programme be handled adequately by another regional institution? (See SACCA, 1993; 1997).

6.2.4 The SADC Protocol on Education and Training

Education and human resources development are perhaps the best routes toward enhancing the scientific and technological capability of the SADC region. Co-operation is provided for, under the *Protocol on Education and Training in the Southern African Development Community* (1997). The provision acknowledges that research and development is a critical area where regional co-operation is necessary for the development of the region. Therefore provisions for co-operation in science and technology are given under Article 8 of the protocol which deals with co-operation in research and development including: a) universities and research, and b) centres of excellence, as follows:

- Member states affirm that for the mastery of science and technology, the region requires first-rate programmes of postgraduate education and training and both basic and applied research for the development of the region;
- Member states acknowledge that higher education systems are major performers of research and are critical for the development of human resources for research and development work; therefore member states emphasise that research efforts in the region should be in line with national and regional needs;
- Member states shall, within ten years from the date of entry into force of the Protocol, develop national Science and Technology Policies to guide the development of science and technology, and to provide the basis on which a regional Science and Technology Policy shall be formulated;
- Member states shall strengthen the research capacities in their countries by allocating adequate resources to universities and research institutes to enable them to pursue socio-economic and technological research;
- Universities are urged to strengthen basic and applied research and consultancy work in order to assist the development efforts of their countries and the region through postgraduate research programmes and those of university research institutes;
- Universities are urged to co-operate with the non-university research institutes to co-operate in the area of research; both types of institute are to forge links with industry, the private sector and other relevant sectors including the SADC sectors, for the purpose of determining priority areas of research and conduct research for those sectors;
- Member states recommend to university research organs and non-university research institutes that they allow access to and jointly develop and share research facilities, including costly sophisticated scientific equipment and materials in order to maximise the use of scarce resources;
- The creation of professional associations of researchers in the region for the purpose of sharing ideas, views and experiences to enhance the quality and relevance of their research programmes should be encouraged and supported;
- In view of the complexity and cost of research, it is envisaged that centres of excellence be established in critical areas of research in order to maximise the use of scarce

resources and expensive research facilities. The distribution of the centres shall aim to achieve regional spread and balance in location;

- The modalities for selection of centres and priority areas of research will be decided upon in consultation with universities and research institutes;
- Member states shall facilitate movement of researchers within the region for purposes of research, and consultancy work by working towards relaxing and gradually eliminating immigration formalities that hinder such free movement;
- A monitoring and assessment mechanism for ensuring that each centre of excellence dispenses its mandate satisfactorily must be developed;
- Where the results of monitoring and assessment are not satisfactory, the research institute concerned will be given a period of two years to remedy the situation, failing which the regional status and support will be withdrawn by the Member States.

Apart from the research institutes, the Protocol also calls for co-operation in higher education, where much of the training for specialisation in technical and scientific fields provides for the establishment of centres of specialisation. These are intended to build capacity for regional training institutions to offer education and training programmes in critical and specialised areas. However, most of the centres of specialisation would be established in just such fields, given that only a few countries in the region have the capacity to train in these areas (Mavimbela, 1999). In that regard the provision allows for a quota system (at least reservation of 5%) for admission into the programmes in the centres of specialisation and states that for purposes of fees and accommodation the centres shall regard SADC students as home students (see the Protocol's Article 7 which deals with co-operation in Higher Education and Training). Notwithstanding the protocol emphasis on postgraduate fields of study, it makes provision for undergraduate-level study in disciplines such as medicine and engineering (Article 7).

To facilitate the implementation of the protocol a regional workshop was conducted to consider the strategies necessary for its implementation. The workshop proposed that the following activities be undertaken in order to achieve the objectives of the protocol as related to research and development:

- Undertake a survey of existing science and technology programmes and facilities in the region;

- Establish an agreement to share information on the establishment of science and technology programmes;
- Improve and support science and technology programmes in the region;
- Identify special focus areas for basic and applied research;
- Establish postgraduate programmes, development strategies, e.g. fellowships and exchanges;
- Involve industry/private sector for contract research and consultancy, as well as student and staff attachments;
- Develop staff-retention strategies;
- Develop regional and international linkages and exchanges;
- Participate in industrial and professional sponsored research;
- Access innovation funds/competitors (Mavimbela, 1999).

The Protocol further provides for an institutional framework for its implementation with the establishment of Regional Technical Committees to serve as guides. The Technical Committees provided for are:

- Basic education;
- Intermediate education and training with sub-committees in teacher education and vocation education and technical training;
- Higher education and training, research and development;
- Life-long education and training;
- Distance education;
- Regional training fund;
- Accreditation and certification;
- Additional technical committees may be established from time to time as the need arises.

6.2.5 Evaluation

Generally within the SADC region it can be argued that the organisation of scientific and technological co-operation is best represented in the Food, Agriculture, Forestry and Natural Resources sector. This has been shown through the establishment of SACCAR, a subset of the SADC institutionalisation process. SACCAR, which is due to be technically merged with the new directorate of Food, Agriculture, Forestry and Natural Resources at the SADC Secretariat, is co-ordinating about eleven separate Programmes. It is still uncertain as to what the new role of SACCAR will be under this new directorate. Whether it will maintain its name or there will be a change of nomenclature, as well as of overall function, is unclear. In October 2001 the current Co-ordinator of SACCAR, Dr K Molapong, noted that he was still engaged in negotiations with the SADC Secretariat to decide the future of SACCAR.

Meanwhile the SPAAR Secretariat commissioned the most recent evaluative study in agricultural research in sub-Saharan Africa in 1999. The study used the six common principles which were adopted in 1990 by SPAAR as the Frameworks for Action (FFAs) that include: institutionalising strategic planning process; improving institutional and management capacity; developing sustainable financing mechanisms for agricultural research; promoting the establishment of donor consultation groups; strengthening research-extension-user linkage; and encouraging regionalisation of research. This study was undertaken to determine the level of adherence to these principles. The result showed a high level of regional collaboration, especially among the three sub-regional organisations of ASARECA, CORAF and SACCAR. Within ASARECA there was 44% collaboration in food and commercial crops, 5.5% in livestock, 17% in natural resources management, 5.5% in post-harvest technology, 5.5% in technology transfer, 11% in information and communication, 5.5 in policy research analysis and 5.5% in genetic resources. Within CORAF there was 44% collaboration in commodity-based crops, livestock 8%; NRM 32%; technology transfer 8%; policy research 4%; and genetic resources 4%. Within SACCAR collaboration has been quite impressive, particularly in the area of human resources development, which is lacking in the other regions, particularly in CORAF. As illustrated in Table 6.3 below, commodity-based regional networks have dominated in the overall co-operation and account for 40% of the general collaboration in all the three sub-regions together, with education and training for human resources development representing 6.6% as the third highest percentage.

TABLE 6.3: Number of areas of collaboration in agricultural research in SSA

Region	Crop Commodities	Livestock	NRM	Post harvest	TT	Education and training	Policy	Genetic Resources
East & Central Africa	8	1	3	1	1	2	1	1
West Africa	11	2	8	0	2	0	1	1
Southern Africa	5	5	3	0	0	2	1	1
Totals	**24**	**8**	**14**	**1**	**3**	**4**	**3**	**3**
Percentages	40	13	23	1.7	5	6.6	5	5

Source*:* Adapted from SPAAR 2000.

The SADC regional MSc programmes have helped to put in place infrastructure meant for skills development and for knowledge production in Africa. This programme is known as the SADC/GTZ project on "Strengthening Postgraduate Training in Agriculture" and was initiated in 1987/88. Over 200 MSc graduates have so far been trained since its inception (Wollny, 2001). This has helped considerably to increase the human resources for agricultural research and development as well as to improve the infrastructure base of the region, which is fundamental for knowledge-based development.

However, the over-reliance on donor funding for these regional centres means that the sustainability of these programmes cannot be guaranteed. For instance, the Sokoine University is facing difficulties to the extent that in the 2000 academic year there was no admission to the programme because of lack of funding and it had to be postponed to 2001 (Wollny, 2001). Similarly, in view of the fact that no funding had been secured, students were not admitted into the programme in the 2001 academic year.[7] The long-term sustainability of the regional scholarship is threatened not only at Sokoine but at the other universities as well. Thus, the GTZ support for the four institutions and scholarships was due to come to an end at the end of 2001.

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[7] Interview with Prof F Sundstol, Technical Advisor SACCAR, 4 October 2001.

Between the 1985/86 and 1990/91 financial years 50 awards were made to scientists and faculty staff from various SADC(C) member states under the SACCAR Small Research Grant Programme. This Grant Programme was sponsored by the Swedish Government through its Technical Assistance Agency (SAREC), aimed at enhancing the experience of promising scientists and researchers and involving them in co-operative activities (Wachinga, 1992:7).

Besides the MSc and Small Grant Programmes of SACCAR being donor-dependent, all the other collaborative network programmes are also donor sustained, either by external bilateral development agencies or through multilateral institutions. For example, the SADC Plant Genetic Resources Centre in Lusaka, Zambia, is sustained by 75% external assistance, with the Nordic countries as a major development partner, while the SADC member countries pay for the remaining 25% of the budget expenditure. Table 6.4 illustrates the details of the programmes and the supporting agencies co-ordinated by SACCAR since 1984. Besides the overall dependence of the SADC Programme of Action on external sources is quite problematic, since there can be no guarantee of the sustainability of the programme. For instance, the number of projects under the SPA is over 350, with an estimated cost of US$8.09 billion. However, approximately 90 per cent of this amount has to be raised from external sources, although close to 50 per cent has been secured (see SADC, 2001).

TABLE 6.4: Regional programmes/projects/networks co-ordinated by SACCAR (funds administered by executing agencies)

Network/Project	Executing Agency	Inception of Project	End of Project	Location	Source of Funds
Land & Water Management Research Programme	SACCAR, NARS	1987	2005	SACCAR	DFID & EU EU funding of New Phase from 2001
Sorghum & Millet Improvement Programme	ICRISAT, NARS	1984	2003	Zimbabwe	USAID, GTZ SADC
Grain Legume Improvement Programme (a) Bean	SADC, NARS,/ CIAT	1986	2002	Malawi Tanzania	SACCAR, ADB, CIDA
(b) Groundnut Improvement	ICRISAT	1986	2002	Malawi	GTZ
(c) Cowpea Improvement	IITA	1986		Mozambique	No donor
Training in Agricultural Research Management	SACCAR, ISNAR, ESAMI	1988	2001	Botswana	ADB
Agroforestry Research Programme	ICRAF	1988	2003	Malawi	CIDA
SADC Plant Genetic Resources Centre (SPGRC)	SACCAR, Nordic Gene Bank, NARS	1989	2002	Zambia	Nordic Countries SADC
Maize & Wheat Improvement Network	CIMMYT, NARS	1994	2000. Phase 2 to start	Zimbabwe	EU, SADC
Strengthening Faculties of Agriculture, Forestry & Veterinary Medicine	Universities GTZ SACCAR	1987	2001	Zimbabwe Malawi Zambia Tanzania	GTZ SADC
Dairy Livestock Productivity Improvement				Not decided	No donor
Regional Vegetable Research & Development Network	AVRDC	1991	2001	Tanzania	GTZ
Southern African Root & Tuber Crops Research Network	IITA, NARS	1994	2004	Malawi	USAID
Wool & Mohair				Not decided	No donor
Aquaculture Research & Development	ICLARM			Malawi	No donor
Biosystematics Network for Southern Africa (SAFRINET)	Plant Protection Institute, ARC, RSA	1996	1999	South Africa	Bionet International DFID, SDC
SADC Animal Agriculture Research Network	ILRI, SACCAR	1999		Not decided	No donor
SADC/USAID/UF/ Heart Water Project	Livestock Sector, University of Florida (USA)	1997		Zimbabwe	USAID

Source: SADC, 2000. Food, Agriculture and Natural Resources; SACCAR 2001, Progress Report June 2000-June 2001.

At the institutional level the decision to transform SACCAR from a Regional Commission into a Sector Co-ordinating Unit in December 1998 has affected the operations and strength of the institution. While this move is considered to be the outcome of a lack of funding for SACCAR's activities and permitted the Botswana government to step in to assist, some commentators disagree. In fact the traditional donors did not agree to that change of status of the Commission, because they felt that this would reduce the momentum for regional co-operation in agriculture research and development, and therefore hamper effective regional integration.

Furthermore, the Protocol of Education is set to improve the human resources development in the region if its provisions are implemented. In April 1999 only two committees (Technical Committee on Scholarship and Training Awards and Accreditation and Certification) were established and operational (Mavimbela, 1999). Then in 2001 the committees for Basic Education and Distance Education were also established, bringing the total number of committees to four out of a possible seven.[8] However, the Protocol itself still awaits ratification, as only seven member countries have ratified it, which falls short of the two-thirds majority of signatories needed for it to come into force. Meanwhile, from the 2002 academic year all students from SADC member states in South African institutions will be paying the same amount for tuition fees as their South African counterparts. This is a significant step forward, because South Africa will be the likely destination for most prospective students and researchers, due to her developed scientific and technological infrastructure. Besides, this agreement will reduce the training cost per student sent abroad for postgraduate training, as it will now be far cheaper to study in South Africa than in the USA, Australia or Europe (SACCAR, 1997; Wollny, 2001). To enhance such initiatives it is important to speed up the establishment of the Technical Committee on Higher Education and Training, since less than one per cent of the secondary school leavers proceed to higher education training in most SADC countries. The establishment of the committee will also help to broaden the fields of training, as they are currently limited to agricultural research and training.

[8] SADC Trade and Industry Review 2001: http://www.sadcreview.com/sectoral%202001/humanresources.htm

However, any prospect of having a SADC sub-regional S&T policy remains an elusive dream, since the Protocol of Education and Training requires at least ten year period after coming into force before such a policy could be considered. As stated in the Protocol "Member States shall, within ten years from the date of entry into force of the Protocol, develop national Science and Technology Policies to guide the development of science and technology, and on the basis of which a regional Science and Technology Policy shall be formulated" (see Article 7 of Protocol of Education). We strongly believe that a ten-year period is too long and that a regional S&T policy could help the countries with least scientific infrastructure to develop appropriate programmes that will foster co-operation and integration better.

The Energy sector of the regional economy is one the specific areas which the SADC countries consider vital to the socio-economic development of the region and it therefore needs regional co-operation. This will enable SADC to harness and develop the enormous energy resources within the region to generate power for both domestic and industrial purposes. This has led to the initiation and implementation of the Southern Africa Power Pool project (SAPP). Already some progress has been made in this field with regard to interconnection of a number of national power grids. However, it does not necessarily involve actual energy research and development, although there are mechanisms for the sharing of managerial knowledge.

The fundamental weakness of all the co-operation programmes mentioned is that they are in most instances donor created or tailored to be donor approved, donor monitored and sometimes donor-executed and evaluated (the three bilateral donors are USAID, GTZ and NORAD, SIDA). What may serve as an impetus to promote co-operation is the initiative by the government of South Africa, which has instituted sub-regional co-operation programmes in S&T by providing funding through the Department of Arts, Culture, Science and Technology (DACST) as well as the National Research Foundation (NRF) post-doctoral scholarship programme, which is open to South Africans and citizens of other SADC member countries. However, the latter scheme has not been utilised so far, as only one award has been made. This is partly due to the problem of staff attrition within the NRF itself.[9] Besides, given the level of its scientific infrastructure and the extent of its knowledge base, South

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[9] Informal discussion.

Africa can play an important role in sustaining effective co-operation and the transfer of knowledge may in some instances be reciprocated by the co-operating partners in the region. For example, the recent news that the Faculty of Agricultural and Forestry Science at the University of Stellenbosch is developing a partnership agreement with Sokoine University of Agriculture in Tanzania is a sign of the healthy development of scientific collaboration in the region (see University of Stellenbosch *Kampusnuus*, 25/10/200:5).

6.2.6 Conclusion

Within the SADC region co-operation on S&T can be found in the Food, Agriculture, and Natural Resources Sector, which have a number of programmes in the different sub-sectors where agricultural research and training has dominated. In this sense the institutionalisation of SACCAR and its co-ordination activities in the creation of scientific infrastructure, particularly in higher training in agricultural sciences and research, has been recognised. A number of scientists have been trained to enhance the skills capacity of the region and its human resources. SACCAR has served as an institution through which donor confidence and trust has not been betrayed.

However, SADC itself still has no unit dealing with S&T, nor will it have until the new restructuring is completed. S&T is still in limbo and, indeed, not yet firmly placed on the development agenda at the Secretariat. One can therefore argue as to whether the success stories of SACCAR and its related activities may be attributed to SADC as an institution. SACCAR is donor-created and over 80% of its programmes are still donor supported, managed or executed. This also means that it is important to speak of international co-operation in the broader sense rather than regional co-operation in a narrower sense.

Until SADC member countries begin to accept greater responsibilities in some of the major programmes of SACCAR, which are designed to provide avenues for sustainability of research and development and human resources development especially at the postgraduate level in science and technology, there is no prospect of a really good sustainable future for scientific and technological co-operation in the sub-region; this conclusion is also applicable to the rest of the continent.

6.3 THE ECONOMIC COMMUNITY OF WEST AFRICAN STATES

6.3.1 Introduction

The Treaty establishing the Economic Community of West African States (ECOWAS) was signed on 28 May 1975 in Lagos (then Federal Capital of Nigeria) by 15 West African countries. The signatories consisted of Benin (formerly Dahomey), Burkina Faso (formerly Upper Volta), The Gambia, Ghana, Guinea, Guinea-Bissau, Côte d'Ivoire (Ivory Coast), Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone and Togo. The Cape Verde Islands joined in 1977, bringing the total membership of the Organisation up to 16 countries.[10]

The original Treaty establishing ECOWAS was, however, later reviewed and the Heads of State and Government within the Community signed a new Revised Treaty at Cotonou, Benin on 24 July 1993. This meant that the original aims and objectives, as well as the socio-economic orientations, of ECOWAS also changed in tandem with Article 2, making it the only economic community in West Africa whose aim was the promotion of economic co-operation and integration of the member states vis-à-vis the vision and objectives of establishing the African Economic Community (AEC) under the auspices of the Organisation of African Unity's Abuja Treaty of 6 July 1991.

In accordance with Article 3(1) of the of revised Treaty (1993): "The aims of the Community are to promote co-operation and integration, leading to the establishment of an economic union in West Africa in order to raise the living standards of its peoples, and to maintain and enhance economic stability, foster relations among Member States and contribute to the progress and development of the African Continent". In order to achieve these set aims of the Treaty, the Community shall by stages ensure, among other things, the harmonisation and co-ordination of national policies and the promotion of integration programmes, projects and activities, particularly in food, agriculture and natural resources, industry, transport and communications, energy, trade, money and finance, taxation, economic reform policies,

[10] On 26 December 1999, however, the Executive Secretariat of ECOWAS received a letter from the Mauritanian government indicating that the country was withdrawing its membership of ECOWAS. Under Article 91 of the Revised Treaty, a year's notice of withdrawal is required to be served. The Community now has 15 member states.

human resources, education, culture, science, technology, services, health, tourism, as well as in legal matters.[11]

6.3.2 ECOWAS Framework for S&T Policy and Co-operation

No sub-regional science and technology policy has been formulated for the ECOWAS. However, the Revised ECOWAS Treaty forms the basis for any future development of such a policy or institutionalisation of S&T co-operation. Article 22 of the ECOWAS Treaty calls for the creation of various Technical Commissions. Although not necessarily the final total of all Commissions to be established (since the Authority may at any time, when deemed appropriate, restructure the existing Commissions or establish new Commissions), the current treaty provisions include the following Commissions:

- Food and Agriculture;
- Industry, Science and Technology and Energy;
- Environment and Natural Resources;
- Transport, Communication and Tourism;
- Trade, Customs, Taxation, Statistics, Money and Payments;
- Political, Judicial and Legal Affairs, Regional Security and Immigration;
- Human Resources, Information, Social and Cultural Affairs; and
- Administration and Finance Commission.

Based upon the above, Chapter Five of the ECOWAS Treaty makes provision for regional co-operation in Industry, Science and Technology and Energy, which are subsequently, grouped under three main Articles (26 for Industry, 27 for Science and Technology, and 28 for Energy). However, for the purposes of our study, we shall dwell on the provisions of Article 27. Thus Article 27 states *inter alia* that member states shall:

- Strengthen their national scientific and technological capabilities in order to bring about the socio-economic transformation required to improve the quality of life of their population;

[11] For more on the aims and objectives, see Revised ECOWAS Treaty, 1993.

- Ensure the proper application of science and technology to the development of agriculture, transport and communications, industry, health and hygiene, energy, education and manpower and the conservation of the environment;
- Reduce their dependence on foreign technology and promote their individual and collective technological self-reliance;
- Co-operate in the development, acquisition and dissemination of appropriate technologies; and
- Strengthen existing scientific research institutions and take all necessary measures to prepare and implement joint scientific research and technological development programmes.

Subsection 2 of Article 27 further notes that, in moving towards co-operation in this area, member states shall:

- Harmonise, at the Community level, their national policies on scientific and technological research with a view to facilitating their integration into the national economic and social development plans;
- Co-ordinate their programmes in applied research, research and development, scientific and technological services;
- Harmonise their national technological development plans by placing special emphasis on indigenous and adapted technologies, as well as on their regulations on industrial property and transfer of technology;
- Co-ordinate their positions on all scientific and technical questions forming the subject of international negotiations;
- Carry out a permanent exchange of information and documentation and establish Community data networks and data banks;
- Develop joint programmes for scientific and technological cadres, including the training and further training of manpower;
- Promote exchanges of researchers and specialists among member states in order to make full use of the technical skills available within the Community; and

- Harmonise the educational systems in order to better adapt educational scientific and technical training to the specific development needs of the West African environment.

6.3.3 ECOWAS Programmes and Projects

Given the above Treaty provisions, the socio-economic development and transformation of the West African sub-region will have to be based on concrete programmes and projects to promote the development and competitiveness of member states. The development of human resources and physical infrastructure is fundamental to the socio-economic transformation of the ECOWAS region. Therefore the ECOWAS Secretariat has over the years tried to initiate a number of programmes to promote greater regional co-operation and development in this direction. Among these are programmes in telecommunications, agriculture, road transport, energy and the monetary sector.

6.3.3.1 ECOWAS telecommunications programme

The group of countries interconnected within the West African Region was (and still is) one of the poorest in the world. Although most ECOWAS countries are close neighbours, direct international links have been very bad, to the extent that international transit telephone calls from one country to another have to be routed through the capitals of the former colonial powers such as Paris (for Francophone countries), London (for Anglophone countries) or Lisbon (for Portuguese-speaking countries, i.e. the Lusophone countries). Thus, based upon the recommendations of the Council of Ministers, the Authority of the Heads of State and Government approved the ECOWAS telecommunications network programme known as INTELCOM I at its May 1979 session in Dakar, with a view to improving and expanding the sub-regional telecommunications network (ECOWAS, 1999:31). INTELCOM I, which is an adaptation of the Pan African telecommunications infrastructure plan (PANAFTEL) priority programme, had three main objectives:

- To provide member states with reliable and regular means of communication in order to promote inter-state trade;
- To reduce the region's dependence on the outside world by developing inter-state communication links (especially the establishment of microwave links between the capital cities of the member states); and

- To assist member states to improve upon their national telecommunications networks (*Contact*, 1992:14).[12]

In order to meet the above objectives, a work plan was formulated in four main stages involving:

- The installation of the remaining portions of the PANAFTEL network by means of microwave links, submarine or co-axial cable links or by satellite (one of the objectives of INTELCOM I was to complete the missing links in the PANAFTEL network in West Africa);
- The establishment of international transit centres;
- The establishment of local line plants, including the boosting of some important localities along the networks with medium-capacity telephone exchanges to take care of border traffic; and
- The establishment of a satellite earth station at Praia in the Cape Verde network (*Contact*, 1992:14).

It was therefore hoped that the development of the telecommunications sector would enable West African countries "to gain control of a technological medium which directly affects the sovereignty of their states, and contributes to the growth of national infrastructures" (*Contac*t, 1992:7-8).

6.3.3.2 ECOWAS agricultural programme

The first tentative step towards the development of a sub-regional programme in agriculture occurred when the Authority of ECOWAS Heads of State and Government adopted an Agricultural Development Strategy as the framework for a common development of agriculture in the West African Community in 1982. At that time agriculture constituted 42% of gross domestic product (GDP) and about 80% of export earnings of most member states,

[12] Indeed, Article 46 of the 1975 ECOWAS Treaty calls on its Transport, Telecommunications and Energy Commission to make urgent recommendations for the rapid realisation in the West African Section of the Pan-African Telecommunications network, and especially the establishment of the necessary links for the economic and social development of the Community, through the co-ordination and mobilisation of national and international resources.

besides being the mainstay of the economy of the sub-region (*Contact*, 1992:15). The main objective of the programme was to promote the development of the agricultural sector in order to support economic development in the region. The programme also laid emphasis on the reduction of food losses and improvement in food distribution and marketing. This strategy also led to the establishment of the Department of Industry, Agriculture and Natural Resources in the ECOWAS Secretariat in 1984 (*Contact,* 1992:15).

During the 1980s the Executive Secretariat took stock of the potential in the field of agriculture in the ECOWAS sub-region, on the basis of which an inventory was prepared for a number of projects and activities to be carried out. The ECOWAS authorities adopted this report. Among the recommendations were the following:

- The establishment of regional centres for seed and cattle production;
- Harmonisation of agricultural pricing policies;
- Control of animal diseases;
- Regional floating weeds control project;
- Regional wild life and plant production programme;
- Upgrading of vaccine production centres in the regions;
- ECOWAS rural supply programme;
- Setting up of a "dump watch" Committee
- Setting up of a regional Seed Committee and initiation of an agricultural research co-operation programme in the region;
- Programme in support of the development of agricultural production and an animal disease control support programme (*Contact,* 1992:15).

There are two major ecological zones in West Africa (Sahel or savannah in the north and the forest or humid tropics in the south), each having a comparative advantage for one form of agriculture. Thus, the Sahel favours livestock and food production and the humid tropics are good for food and cash crop production. In this case the Community took a decision to establish eight cattle-breeding centres and seven seed-production centres in selected member states, with the catchment area of each of the centres serving a number of countries. On the one hand, the cattle-breeding centres are designed to produce improved breeding stock of the trypanotolerant N'Dama and Maturu breeds for the humid zone, while Zebu breed improvements would be produced for the Sahel zone. On the other hand, the seed-production centres are intended to advance breeder seeds of major crops to the level where foundation seeds can be distributed to seed multiplication units, which will in turn supply local farmers or seed companies.[13] Table 6.5 shows the centres and the type of animal breed or crop production they are to concentrate on.

TABLE 6.5: Proposed ECOWAS regional centres for animal breeds and crop seeds production

Centre Name and Location	Animal Breeds or Crops
Livestock Development Project (The Gambia	N'Dama
Marahoue Ranch (Cote d'Ivoire)	N'Dama
Madina Diassa (Mali)	N'Dama
Famoila (Guinea)	N'Dama
Kedougou (Senegal)	N'Dama
Upper Ogun Ranch (Nigeria)	N'Dama
Ezzilo Ranch (Nigeria)	Muturu
Kaedi Ranch (Mauritania)	Zebu
Zaria (Nigeria)	Rice, Wheat, Sorghum, Maize, Groundnut, Cotton
Bouake (Cote d'Ivoire)	Rice, Maize, Sorghum, Groundnut, Millet, Soyabean, Cowpea
Modolo (Mali)	Groundnut, Sorghum, Rice, Maize, Cowpea, Soyabean
Richard Toll (Senegal)	Rice, Groundnut, Maize
Kaedi (Mauritania)	Sorghum, Millet, Maize, Rice
Lossa (Niger)	Cowpea, Millet, Sorghum
Rokurp (Sierra Leone)	Groundnut, Sorghum, Rice, Maize, Cowpea

Source: *Contact,* July 1992 p.16

[13] In spite of the fact that the West African sub-region embraces two main ecological zones, these two zones are not mutually exclusive as some cereals, such as rice and maize, can be produced in both ecological zones; with animal breeding some breeds also overlap the zone boundaries.

6.3.4 Evaluation

Within the telecommunications programme ECOWAS began the implementation of INTELCOM I in 1983 and, through the ECOWAS Special Fund for Telecommunications (SFT), the Community was able to finance the programme between 1983 and 1992. This had actually begun in May 1982, when the Board of Directors of the Fund authorised a financial package of US$12.5 million for financing the programme in seven member states. This initiative was the first project to be funded with ECOWAS funds (Asante, 1990:109).[14] An external evaluation undertaken by the International Telecommunications Union (ITU) notes that the programme attained about 95% of its initial objectives (ECOWAS, 1999:12). In fact, INTELCOM I made interstate telephone links within the West African region possible. That is, it brought about direct telephone communications (without calls having to pass through the capitals of the developed countries) among the West African States (*The West African Bulletin*, 1997:37). This initial success of INTELCOM I prompted the Authority of the Heads of State and Government to direct the Executive Secretariat to develop and implement a second ECOWAS Telecommunications priority programme to be known as INTELCOM II.

Therefore in 1997 INTELCOM II was launched with the principal objective being to "provide the Community with a regional telecommunications network that is modern, reliable, and capable of offering a wider variety of services, including multimedia and wide band services" (ECOWAS, 1999:132), in order to reduce transits through countries outside Africa, as well as to improve the direct links between the member states (ECOWAS, 1999:132). The second initiative includes criteria of convergence in the following areas: the telecommunications regulatory framework, telephone density, full digitalisation of the network, integrated services network (ISDN), intelligent networks, cellular technology, information super-highway, standardisation of telecommunications hardware, and industrialisation and preferential community treatment in the supply of telecommunications products (*The West African Bulletin*, 1997:36).[15] Another important aspect of the agreement was the creation of the Lome Regional Telecommunication Maintenance Centre (LRMC).

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[14] Article 50 of the Lagos Treaty established the ECOWAS Fund for Co-operation and Compensation and Development.

[15] See ECOWAS (1999:132-137) Annual Report for more details on INTELCOM II.

However, the implementation of INTELCOM II could not start immediately due to financial constraints. The total cost for conducting the studies is estimated at US$328 400.00. The ITU, being the technical sponsor and supervisor for the feasibility studies conducted for INTELCOM II, has agreed to provide funding of US$222 000, which represents 67% of the cost, with the remaining US$106 400.00 (33%) to be provided by ECOWAS. Due to the ITU's own internal changes in the last quarter of 1998, however, funding was suspended (ECOWAS, 1999:61-62). Although the SFT fund provided support for INTELCOM I, its future remains uncertain and perhaps unsustainable because its capitalisation is based on external borrowing by the ECOWAS Fund from, for example, the European Investment Bank. It should be emphasised here that, if all the member states were to pay their annual contributions, such regional programmes could be implemented without necessarily relying too much on external donor support (both grant and loan).

In fact, as at 30 September 2000 most member states were extensively in arrears in their contributions to the various budgets and funds of the ECOWAS institutions. In the Executive Secretariat budget alone only six member states, including Benin, Burkina Faso, Cote d'Ivoire, Mali and Nigeria and Togo, were not in arrears up to 1999, with Mali and Togo having paid up their contributions to the Executive Secretariat budget for 2000. The total arrears outstanding amounted to UA 31.7 million or US$38.4 million in 1999. Mauritania, which withdrew its membership, now owes 16 years in arrears payments, while Liberia owes 20 years. As illustrated in Table 6.6 below, ten out of the sixteen ECOWAS member states owe accumulated arrears of between two and twenty years.

TABLE 6.6: Arrears of contributions to ECOWAS Secretariat as at the year 2000

Country	Years in Arrears	Total Amount of Arrears (US$ million)
Liberia	20	11.5
Mauritania	16	6.4
Gambia	11	2.9
Sierra Leone	11	3.7
Cape Verde	10	2.5
Guinea-Bissau	10	2.8
Niger	6	2.1
Guinea	5	2.06
Senegal	3	1.29
Ghana	2	1.97
Total		**37.22**

Sources: Compiled from ECOWAS Executive Secretariat Annual Report 2000, p. 85.

Furthermore, the ECOWAS Fund for Co-operation, Compensation and Development, as established, is mostly intended for providing compensation to member states which have suffered losses as a result of the establishment of community enterprises and the application of the liberalisation of trade within the Community. Its function of promoting and financing development projects is yet to be extended to scientific and technological research and development, even in member states. Similarly, to supplement the efforts of the ECOWAS Fund, the Federation of the West African Chambers of Commerce established the ECOBANK in September 1985 to help mobilise financial and other resources to promote development and trade (Asante, 1990). So far, ECOBANK activities do not cover the whole sub-region and are limited to trade only. However, developing the appropriate technology and technical skills within the telecommunications sector should be of higher priority. For instance, in 1997 the average level of technical breakdowns for 100 telephone lines in West Africa was at the very high rate of 78.1, as compared to 8.9 in America, 20 in Europe, and 44 in Asia (ECOWAS, 1999:26). Besides INTELCOM II calling for the modernisation of the telecommunications infrastructure, the engineers and technicians required to provide adequate services are very few. Hence, developing the appropriate numbers of technically skilled people at the sub-regional level should be a matter of high priority for the Executive Secretariat and the individual national governments.

The ECOWAS agricultural programme has also not been without problems in terms of implementation. For example, a document which was prepared by the ECOWAS Agricultural Division in 1999 indicated that out of the eight regional centres that had been selected for cattle-breeding programmes, only three had been developed since the idea emerged in 1987. These include the Marahoue Ranch in Cote d'Ivoire, the Famoila Farm in Guinea and the Madina Diassa Centre in Mali (Ugoh, 1999:18). Related to the breeder cattle programme is the support programme for animal control that incorporates the pan-African rinderpest control campaign for West and Central Africa, which we discussed in the previous chapter under the OAU. This includes the upgrading of four sub-regional vaccine production laboratories at Dakar Hann in Senegal, Bamako in Mali, Bingerville in Cote d'Ivoire and Von in Nigeria. However, in 1994 the ECOWAS Secretariat failed to secure external funding for the upgrading of these laboratories (Ugoh, 1999:18). It is such programmes, which the ECOWAS Fund could support.

Meanwhile, given that the provisions of the 1982 and 1987 agricultural development policy strategies remain largely unfulfilled, Ministers of Agriculture of the ECOWAS Food and Agriculture Commission endorsed the introduction of a Common Agricultural Policy (CAP) for West Africa in January 2001 at Bamako, Mali. The new Common Agricultural Policy is expected to be adopted by the Authority of Heads of State and Government and then replaces the Regional Agricultural Development Strategy, which was adopted in May 1982 by the ECOWAS Leaders. Thus CAP aims at creating a congenial environment for "investment in agricultural development in the sub-region, positioning the regional agricultural economy in the world market; promoting free trade in agricultural products and inputs in the sub-region, as well as integrating national policies and programmes in agriculture, fisheries and livestock development".[16]

The liberalisation of the agricultural sector in line with World Trade Organisation (WTO) Agreements seems to motivate the new policy. However, the development of these resources to take advantage of the opportunities offered by globalisation will require effective and efficient regional capacity in agricultural research and development. Also at the core demands of the WTO Sanitary and Phytosanitary Agreement is the need for sound scientific and technological research to unlock the protective markets of the advanced countries for

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[16] ECOWAS 2001. "ECOWAS Food and Agriculture Commission adopts Common Agricultural Policy" http://www.ecowas.int./sitecedeao/English/pub-4-13-2001.htm Press Release 31 January 2001.

which most of the region's agricultural products are destined. The private sector, as envisioned in the policy, has to be involved in the funding and conduct of agricultural R&D and in the transfer of technology, if the implementation of the policy is to be really positive and enhance West African sub-regional development. As indicated in Chapter 3 of this study, the post-national development of scientific and technological R&D through private sector participation, following market liberalisation and the privatisation of stated-owned enterprises, is yet to be realised in Africa.

Despite the Treaty provisions calling for the establishment of a Scientific and Technological Commission within the ECOWAS organisational framework, there is no such institutional body that is functional. In the light of this the efforts of the Executive Secretariat regarding regional S&T, as described above, are limited to agriculture and telecommunications, and even in these fields there are no plans in place for regional centres for human resource development. Even COROF, which represents both central and western Africa, has no education and training programme nor any collaboration in post-harvest technology development, as we saw in Table 6.3 under the discussion of SADC.

Political instability in the sub-region remains a major problem, which means that very scant resources are left to deal with real development issues. Political turmoil in Sierra Leone, Guinea, Liberia and Cote d'Ivoire has set the development process in the sub-region back many years. However, the creation of the ECOWAS Parliament is seen as further hope for promoting regional development and integration. Almost a decade after its establishment in the Treaty provision, the Parliament was inaugurated in 2000 and held its first session in Abuja in January 2001. The Parliament established a number of Committees, among which is the one for Energy, Technology and Scientific Research. The responsibilities of this Committee cover matters relating to the strengthening of the national scientific capacities of member states with a view to improving the quality of life of the community's citizens; reduction of dependence on foreign technology, promotion of local technology and the promotion of collective technological self-reliance; strengthening of scientific research institutions; and, above all, the promotion of joint scientific research and technological development programmes (ECOWAS Parliament Rules of Procedure, 2001). With the creation of the Parliament and the Committee on Energy, Scientific and Technological Research, some officers at the ECOWAS Secretariat believe that the Executive Secretariat will be forced to have concrete programmes in S&T in place to enable it to present a good annual report to both the Parliament and its Committee.[17] Besides this, the problem of how to co-ordinate and harmonise the activities of ECOWAS and the Economic and Monetary Union of West Africa (UEMOA), mainly involving Francophone countries, in order to avoid the duplication of efforts, remains a great challenge. For example, ECOWAS has an Industrial Policy and has formulated a new Community Industrial Development Policy (CIDP), while at the same time the UEMOA also has its own industrial policy, which is currently under implementation. In the interim the Parliamentary Committee will have to deal with these matters until an organisational framework for S&T is created at the Executive Secretariat. This is the major task to which Dr Mohammed Ibn Chambas, the newly appointed Executive Secretary, will have to pay proper attention.

Meanwhile, in 1983 ECOWAS and UNESCO signed an inter-institutional co-operation agreement. This was reviewed in September 2000 in various areas, including education, culture, science and communication. In the field of education, the two Institutions resolved to pursue the harmonisation of education policies and programmes, and ensure the equivalence of certificates awarded in West Africa. They also discussed the establishment of centres of excellence and of specialised institutions having sub-regional scope (*The West African Bulletin*, 2000:46-47). We hope that S&T education and training will be given a higher priority, which is needed to ensure the capacity for the creation of knowledge for development.

Furthermore, as in SADC region where the government of South Africa is implementing programmes through some government departments and the NRF to foster scientific and technological co-operation with the sub-region as well as on the continent, the newly created Nigerian government's Ministry of Co-operation and Integration in Africa at the Presidency is also taking a similar approach aimed at promoting S&T co-operation within ECOWAS and the rest of the continent. The Co-operation and Integration Ministry aims at establishing a Technical Co-operation Fund (TCF) which "will provide the necessary financial resources to promote and encourage an effective science and technology exchange programme (STEP) between Nigeria and other African countries" (Gana, 2000:30).[18] If this project is successful, it may complement future ECOWAS initiatives in S&T.

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[17] At the time of my visit to the ECOWAS Secretariat in May 2001 the new committee had yet to convene its first sitting.

[18] The main objectives of the TCF include: a) to promote technology transfer through technical co-operation; b) to facilitate capacity building in research and development centres in Africa; c) to promote the exchange of high-level research experts in science and technology; d) to generate new ideas for African Development

6.3.5 Conclusion

Providing an appropriate and institutionalised organisational structure for S&T development and co-operation at the sub-regional level in West Africa remains a monumental task facing ECOWAS. Although the Treaty provides the basis for developing a comprehensive institutional framework in S&T development and co-operation, all the bodies which should have made possible the realisation of such a framework have failed. In particular, the Executive Secretariat has failed to play its part in the establishment of the necessary structures, as is evident from the Executive Secretary's Annual Reports, which are presented to the Authority of Heads of State and Government. Although the newly functional ECOWAS Parliament has taken the initiative, it remains to be seen how the Executive Secretariat will respond.

In spite of its programmes in telecommunications and agriculture, no real research, either applied or basic, and no human resource development programmes are conducted at the initiative of ECOWAS and with its own resources. Furthermore, without taking away its policy initiative, ECOWAS programmes in the areas of telecommunications, agriculture, energy and road transport remain largely dependent on external donors. The major challenge facing ECOWAS is to address the fundamental issue of not having an organisational structure within the Executive Secretariat to oversee the broader concerns of S&T development in the sub-region.

6.4 GENERAL CONCLUSION

What we have done in this chapter is to look at the sub-regional approach towards the development of scientific and technological co-operation programmes within SADC and ECOWAS. The common thread in both institutions is that their establishment Treaties call for scientific and technological co-operation among their member states to develop their national and regional scientific capability. However, neither institution has any organisational

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through co-operative research and development; e) to reverse the brain drain from Africa to the developed world in favour of a fresh movement back to Africa of highly skilled manpower; f) to facilitate co-operation and integration in Africa through technology transfer and the diffusion of scientific innovations; g) to provide sustainable funding for a scientific and technical exchange. Meanwhile, at the time of the researcher's visit to Abuja, Nigeria, in May 2001 the Nigerian government was still involved in discussion with the ECA in order to develop a full document for the operation of the TCF. The initial amount for the TCF is still to be decided.

framework which is able to deal with the broader context and the varied fields of S&T for socio-economic development and, therefore, there is no body to help develop and prioritise scientific and technological R&D and infrastructure at the sub-regional level.

Nonetheless, in view of the importance of the agricultural sector in both national and regional economies of both geographical purviews of the two institutions, agricultural science and research dominates their programmes and they have created organisational structures specifically for that purpose. This also applies in SADC through the SACCAR and related activities of the Food, Agricultural and Natural Resources Sector. Specifically, SACCAR has been the main body for effective agricultural R&D, as well as human resource development, in the Community since 1984. However, the on-going restructuring and rationalisation of SADC since March 2001 does not show what the future of SACCAR, as the main body for regional agricultural research and training, would be within the organisation. Within ECOWAS the creation of the Department of Industry, Agriculture and Natural Resources at the Secretariat in 1984 provided the initial organisational framework for the common development of agriculture in the sub-region. However, until there is someone or a particular institution to take responsibility for, and address, the broader question of S&T policy development, regional co-operation, as well the co-ordination and harmonisation of individual national policies and programmes, regional programmes will be very difficult to formulate and implement.

Furthermore, a fundamental weakness of all the co-operation programmes mentioned above, as well as of some which may not have been mentioned, is that they are often donor created or tailored to be donor approved, donor monitored and, if possible, donor executed and evaluated. A regional programme often depends on both bilateral and multilateral donor institutions for funding and by implication has to depend on the research interests of such organisations in order to secure funding. This also means that, whenever there is a change of research agendas in those institutions concerned, whether those of SADC or ECOWAS, research proposals have to be reviewed to accommodate donor demands, making long-term sustainable funding for research programmes unattainable under such circumstances. The over-reliance on external donor grants for the development of sub-regional programmes and implementation has, however, become a matter of concern to regional policy-makers. This donor dependence can only be changed or minimised through active political commitments from leaders, especially the payment of their various contributions to promote scientific research and development.

The necessary infrastructure for scientific research and training is seriously lacking in most member states of both SADC and ECOWAS. On their own, most of these countries are unable to develop the appropriate infrastructure required for national development, let alone what is needed for the whole region. This implies that very strong commitments have to be made to the establishment of effective and efficient regional infrastructures for scientific training and development. In this light, the question may be asked how best ECOWAS and SADC, as well as other sub-regional institutions, including the two main regional institutions – especially the OAU and ADB – can learn from similar institutions elsewhere. This is the main subject for discussion in the next chapter, where we look especially at the EU and ASEAN.

CHAPTER SEVEN

SCIENTIFIC AND TECHNOLOGICAL CO-OPERATION IN THE EU AND ASEAN REGIONS: LESSONS FOR AFRICA

7.1 INTRODUCTION

At a time when the world is still characterised by increasing concerns for national systems of innovation in the form of technonationalism *or technoliberalism,* and the new trends of *technoglobalism,* no one would expect scientific and technological co-operation to occupy the minds of national planners and policy-makers. However, the era of "Big Science" and now "Megascience", as well as concerns for global competitiveness, has made regional co-operation in S&T even more important and some regional institutions have made very significant progress that holds lessons for Africa. Therefore the present chapter provides a review of some of the trends in regional co-operation in other regions of the world in order to ascertain what lessons Africa can derive from them. However, most emphasis is placed on the European Union (EU) and the Association of South-East Asia Nations (ASEAN). The former represents the best example of regional co-operation and integration from the developed world, while the latter is said to be replicating the same efforts and is thus considered one of the best examples of the regional co-operation and integration process that is evolving in the developing world. The science programmes of these two institutions are therefore examined below. The first part of the discussion will focus on the EU scientific and technological co-operation policies and programmes, while the second section will dwell on ASEAN's S&T co-operation policies and programmes.

7.2 THE EUROPEAN UNION

7.2.1 Introduction

The genesis of the European Union (EU), the precursor of the European Community (EC), began with the establishment in 1952 of the European Coal and Steel Community (ECSC) by the Treaty of Paris, bringing together Belgium, France, Germany, Italy, Luxembourg and the Netherlands with the aim of creating a common market in steel and coal. Then in 1957 the European Atomic Energy Community (EURATOM) and the European Economic

Community (EEC) were created by the Treaties of Rome.[1] However, it is the EEC which has been the cornerstone of the development of European co-operation and integration, which has now evolved into its present form as the EU, since the coming into force of the Treaty of the European Union (the Maastricht Treaty) on 1 November 1992 (Bright, 1995:2-3).

The European Commission, which is one of the main institutions of the EU, performs an executive and civil service function and is the source of all legislative proposals. In other words, the Commission supervises both the application and implementation of Community legislation and the application of the day-to-day running of Community policies, including the funding of various Community programmes. The European Commission has 20 members and is composed of 23 Directorates-General, with each Directorate-General being headed by a Director-General. There is one Commissioner responsible for Research and currently, under him, is the Directorate-General for Research.[2]

In 1999 the present Commissioner for Research, Philippe Busquin, put forward a proposal towards defining a new European Research Area (ERA), which is being realised in the Sixth Framework Programme, set to run from 2002-2006 (see further discussion on Framework Programmes later). In the light of this, the mission of the Directorate-General for Research is also evolving around the ERA initiative, which is to help:

- develop the European Union's policy in the field of research and technological development and thereby contribute to the international competitiveness of European industry;
- co-ordinate European research activities with those carried out at the level of the Member States;
- support the Union's policies in other fields such as environment, health, energy, regional development etc;
- promote a better understanding of the role of science in modern societies and stimulate a public debate on research-related issues at European level.[3]

[1] According to Desmond Dinan (1994:33), although both treaties were signed on 25 March 1957 and officially called the Treaties of Rome, in practice only the EEC Treaty, which is the more important, is known as the Treaty of Rome.
[2] For details about the historical evolution of the EU and the activities of its various institutions see Bright, 1995; Holland, 1993; Guéguen, 1996; Dinan, 1994; Archer and Butler, 1996; Laffan, 1992; Harrop, 1989.
[3] Research Directorate-General: http://www.europa.eu.int/comm/dgs/research/index_en.html.

It is important for us to look at European scientific and technological co-operation and how it has evolved into the present Policy Framework Programmes since the early 1980s.

7.2.2 European S&T Co-operation

Ruberti and André (1997:327) note that, from a scientific viewpoint, European researchers appear to turn in particularly good performances in clinical medicine, biomedical research, chemistry and physics, while they do less well in biology and engineering sciences. In technological and industrial terms the strength of Europe lies in fields such as chemistry and pharmacy, in which European firms occupy world-leading positions. Also, in sectors linked to public procurement European firms are competitive in the aerospace and telecommunications fields (Ruberti & André, 1997:327).

In these major fields of specialisation certain countries in particular are found to be in a leading position. Thus excellent results in European pharmaceutical and chemical research come first and foremost from Swiss, German and French firms. The British are leaders in European medical research. The British, French and Germans largely dominate European technology in the fields of telecommunications and aerospace. In addition the Swedes have high standards in biomedical research. There is a well-established tradition of physics and mathematics in Italy, while knowledge on polar research has been accumulated by Norwegian researchers; Finnish research potential lies in neuro-informatics, to name a few (Ruberti & André, 1997:328). According to Ruberti and André, it is because of these fairly narrowly delineated national capabilities that Europe was quick to realise the significance of European co-operation in the area of S&T, which has been carried out in various forms since the era immediately following World War II.

7.2.3 Forms of European S&T co-operation

Generally there are three science systems in Europe: national, intergovernmental and European Union (EU). However, in terms of co-operation, Ruberti and André (1997) identify two main models of scientific and technological co-operation in Europe: the intergovernmental model and the "federal" or Community model. The inter-governmental programmes involve co-operation among non-European Economic Community (EEC) and EEC countries and are only partially embedded in the Community (Sharp, 1997). Increasingly, however, these distinctions between intergovernmental and Community level co-operation are becoming very blurred (see Framework Programmes below), while agreements with third party countries for international research and technological co-operation further blur the distinctions at the Community or Europe-wide levels. Encouraging these forms of co-operation are the treaties of EURATOM and the EC (and now the EU Treaty).

7.2.3.1 The intergovernmental model

According to Ruberti and André (1997), the first initiative of European scientific co-operation emerged in the field of basic research, far from the market and from military applications. Thus, shortly after the end of the Second World War, nuclear physics was to become the first area in which European countries embarked on a joint project. This was because it appeared as a rapidly expanding sector that held out even greater promise for the future. Furthermore, particle physics research was (and still is) expensive, requiring large-scale equipment beyond the means of a single country. Hence in 1954 the French centre known by its acronym CERN - Centre European pour la Recherche Nucleaire (European Organisation for Nuclear Research, currently the European Laboratory for Particle Physics) – was established (Ruberti & André, 1995:18; 1997:329).

Based on the CERN model, other European co-operative organisations were set up in subsequent years. ESO (European Southern Observatory), the European astronomical laboratory for the Southern Hemisphere, was set up in 1962. In the fields of the life sciences and technologies co-operation has taken several forms. In 1965 EMBO (European Molecular Biology Organisation) was set up. A large proportion of its resources is devoted to funding a fellowship programme. After much hesitation European governments also decided in 1973 to set up EMBL (European Molecular Biology Laboratory). EMBL is an association of 15 countries and is a European centre of excellence in molecular biology.

EMBL has pursued a policy of networking its installations with other centres of excellence (or units). Its main research programmes are organised through the development of out-stations from the main laboratory in Heidelberg in Germany. These out-stations include: Hamburg (linked to the DESY sources of synchrotron radiation); The Institute Laue-Langevin (ILL) in Grenoble, which is managed jointly by France, Germany and the United Kingdom, has been operational since 1971 and serves as a powerful source of neutrons, supplied by a high-flux research nuclear reactor. Also in Grenoble, not far from the ILL, is the ESRF (European Synchrotron Radiation Facility), which was inaugurated in 1994, and which at present is the world's most powerful source of synchrotron radiation. Hinxton, near Cambridge, hosts the European Bioinformatics Institute (Ruberti & André, 1997:329). Then there is the newly established European Mouse Mutant Archive (EMMA) centre at Monterotondo, near Rome, which specialises in mouse genetics (André, Fasella & Ruberti, 1998:88).

The central mission of EMBL is to promote the development of molecular biology throughout Europe in order to foster cutting-edge research that opens up new fields; to develop new techniques and instrumentation; as well as to provide advanced training and services to the scientific community. Therefore, over the years EMBL has carried out landmark research in systemic genetic analysis of embryonic development in *Drosophila*; molecular cell biology of membrane traffic, elucidation of RNA maturation, transport and translational control. Other achievements include the introduction of biocomputing and bioinformatics in Europe, the development of enabling technologies such as the use of synchrotron radiation in biology, cryoelectron microscopy, and mass spectrometry for protein identification, all exemplified by the work of the out-stations mentioned above (Kafatos, 2000:1401).

The desire to improve co-ordination of basic research activities in Europe led to the establishment of the European Science Foundation in 1974. The Foundation now has 55 national research organisations from 20 different countries as associates. It manages projects and runs networks on subjects from various disciplines in the exact and social sciences (Ruberti & André, 1997).

A large proportion of these co-operative activities are based around large facilities. A further example of this is research in controlled thermonuclear fusion. Unlike the initiative previously mentioned, Europeans decided in this case to use the framework of the European Union to channel their efforts. The European Union programme on fusion is based on two elements: the co-ordination of activities carried out in all the laboratories in Member States (the programme is a totally integrated European programme) and the joint operation of an experimental fusion research facility, the JET (Joint European Torus). JET is based at Culham, near Oxford, United Kingdom, and has been operational since 1983. This facility functioned until 1998. A few years from now, it has been anticipated, the research carried out in thermonuclear fusion over the entire world could be executed within the framework of an international co-operative project, ITER (International Thermonuclear Experimental

Reactor), which brings together the European Union, the United States, Japan and Russia (Ruberti & André, 1997:329).

Space is another field which European scientific and technological co-operation is exemplified. In 1962 ESRO (European Space Research Organisation) was set up through the initiative of scientists, with the objective of enabling them to exploit space technologies for research at the European level. To give Europe its own launch capacity another organisation, ELDO (European Launcher Development Organisation), was set up at the same time. However, while ESRO quickly proved that it could attain the objectives set, this was not the case with ELDO and work to produce a European launcher ended in failure (Ruberti & André, 1997:330). Having learnt its lesson from this failure, the European government set up the European Space Agency (ESA) in 1973. The Agency operates on a dual formula of activities: mandatory scientific research programmes and optional technological programmes, in which Member States can participate "a la carte". It is under the ESA that the Ariane launcher rocket was developed and it is now operated commercially by the Arianespace Consortium (Ruberti & André, 1997).

In the aircraft industry, which was briefly mentioned in the introductory chapter of the study, European co-operation developed first on an industrial and commercial level. The AIRBUS consortium was set up in the mid-1960s at the initiative of the British, French and German governments and a number of companies in the industry. It rapidly turned out to be a viable commercial company. European co-operation in the aircraft industry is now starting to spread to research (Ruberti & André, 1997:330). Here co-operation takes the form of "technology alliances" involving European enterprises, which are now set up at three levels: national, intra-European and international, particularly with the aim of penetrating distant markets. These alliances have grown remarkably over the years and are now stable, showing 25% growth on average (André, Fasella & Ruberti, 1998:87). The proportions of alliances vary from one sector to another at the national, European and the international level. However, the one area in which intra-European alliances are by far the most widespread is in the field of aerospace, with alliances estimated as 42% of the total research industry (André, Fasella & Ruberti, 1998:87).

Nevertheless, European co-operation in aerospace is not typical of the situation pertaining in industry. Co-operation is relatively easy to establish in basic research, but seems to be more difficult the closer the activities are to the market. Under the two-fold effect of the creation of the European internal market and the continual increase in research costs, large European companies in the car industry, information technologies, pharmaceutical and chemical industries now tend to work more closely together. However, due to the size of the financial interests at stake, and often the effect of industrial alliances on a global scale, co-operation is more difficult to implement in these fields (Ruberti & André, 1997).

Apart from European research into fusion, or private initiatives like Ariane-Space or AIRBUS, all the co-operative organisations mentioned so far are intergovernmental in nature. This is one of the two main models for co-operation in science and technology in Europe.

7.2.3.2 The community model

From the early stages of European reconstruction after the Second World War research has been an integral part of the process. In fact, the ECSC Treaty signed in 1951, which set up the ECSC (European Coal and Steel Community), made explicit provision for research activities. The Treaty (instituting the European Community) mentioned research in the context of agricultural policy. The coming into force of the 1986 Treaty has broadened the area of research within the Union and has given the European Commission a greater say in fostering co-operation and co-ordination of research in the Community.

The Community also provided the framework for setting up the COST (Co-operation in Science and Technology) co-operation programme in 1971. Despite the role played in its operation by Community institutions (the Council provides for the political secretariat of COST, and the Commission for the technical secretariat), COST is an intergovernmental co-operation structure. It is a framework for "a la carte" projects financed by national research budgets (Ruberti & André, 1997:330). Its programmes have increased to cover ten industries: information, telecommunication, transportation, metallurgy, oceanography, agriculture, food, environmental protection and medical research (Thacker-Kumar & Cambell 1999:107).

Another important development was the establishment of the European Union's Joint Research Centre (JRC) in the late 1950s. It consists of eight institutes, each of which specialises in a particular field, located at five different places in Europe.[4] With initial focus

[4] The institutes include the Institute for Reference Materials and Measurements (IRMM) at Geel in Belgium; Institute for Transuranium Elements (ITU) at Karlsruhe in Germany; Institute for Advanced Materials (IAM) at Petten in the Netherlands; Institute for Systems, Informatics and Safety (ISIS); Environment Institute (EI); Space Application Institute (SAI); the Institute for Health and Consumer Protection (IHCP) at Ispra in Italy; and the Institute for Prospective Technological Studies (IPTS) at Seville in Spain.

on nuclear research, the JRC conducts "in-house" research that provides the EU with neutral, objective expertise concerning its regulatory and normative activities relating to economic, industrial and social policies. It also provides expert analysis on issues connected to the environment, agriculture and energy, and at the same time works with outside clients, both public and private (Ruberti & André, 1995:190; Lloyd, 1993:53).

Despite these co-operative research activities from the 1950s to the early 1970s, by the latter part of the 1970s Europe realised that it was falling behind its competitive partners in the international market in certain high-technology product sectors and therefore required a policy rethink for research programmes undertaken from the early 1980s. This led to the introduction of the Framework Programmes, making the 1980s (as Thacker-Kumar and Cambell (1999:107) put it) "a watershed for European technology policy, as the European Commission shifted its focus towards major collaborative efforts". For example, the JRC Institute for Prospective Technological Studies (IPTS) has been commissioned to collect and analyse data on recent technological developments and to help disseminate this information to European decision-makers. The task also includes "analysing the comparative state of particular technological advances in Europe and the rest of the world and notably among Europe's chief competitors" (Cresson, 1997:xiii). The IPTS was established much later than the other JRC institutes

7.2.4 The Framework Programmes and the Funding and Direction of European S&T

Choosing the fields of scientific and technological research and therefore the funding of European research and technological development proved to be a very progressive decision over the years. All the co-operative research activities in Europe in 1995 amounted to 13 percent of the total European public expenditure on research, while most of the remaining 87 percent was spent at the national level, much of which was controlled by powerful research organisations (Ruberti & André, 1995:19). The purpose of the European funding system is not only for knowledge generation. In other words, the European Community had no remit to promote science for its own sake in the recent past; thus its research plans have had to be geared to the economic advantage of the Community (Herman, 1996:78). This is because, by the late 1970s, it became apparent that Europe's erstwhile pre-eminence in science was being eclipsed by the USA and Japan and, more so, that the members were also losing the battle for markets and technology and therefore there was a need to give a European dimension to research, to standards and to the market base (Herman, 1996:78. For further analysis of the high-technology trade see L D'Andrea Tyson, *Who's Bashing Whom?* 1992).

Out of the above concerns and imperatives arose the Framework Programmes in the early 1980s, "designed to build collaboration in science with potential to improve economic competitiveness" (Herman, 1996:78). The Framework Programmes have been the central expression of the Community's research policy and is now becoming the principal tool for building the new European Research Area (Mitsos, 2001). The Council of the European Union and the European Parliament through a complex co-decision procedure usually approves the Framework Programmes every five years. It mobilises a significant number of resources to both enhance the development of the European research networks and advance a number of key research priority areas (Mitsos, 2001). In other words, "the Framework Programme is primarily aimed at improving scientific and technological capability and competitiveness in the EU via collaborative research and technological development (RTD) projects involving partners from the Member States" (Independent Expert Panel, 2000).

Under the Framework Programmes the EU offers half the cost of projects (*extra-muros* or shared costs) in areas it has considered and specified as being of particular interest. Researchers, who may work either in industry or in the public sector, must apply in groups involving at least two member states and projects are assessed by peer review processes managed by the European Commission. The cost of these accounts for a further 4% of European outlays for R&D (Herman, 1996:79). Consequently a number of co-ordinated R&D and technology programmes in information technologies, biotechnology and now also nanotechnology are taking place under the sponsorship of the EU. These include the ESPRIT, EUREKA, R&D in Advanced Communication Technology for Europe (RACE), and the Basic Research in Industrial Technologies (BRITE) among others, all in an attempt to increase competitiveness in Europe via European producers. This is a situation which Davies (1988) and Frick (1988) see as resulting in "European manufacturers …[being] part of the core rather than part of the periphery" (see Malecki, 1991:195).

Thus, the First Framework Programme for the European Community was adopted by the Council of Ministers in 1983 and was associated with financial authorisation which doubled the previous R&D budget; it ran from 1984-87 (Durand, 1991:50). According to the European Community (EC) Commission, the purpose of this programme was to integrate all Community aid to R&D into a single, coherent system, capable of ensuring continuity beyond twelve months. It included all past aid to nuclear and non-nuclear energy programmes, but added research into raw materials, recycling of industrial waste, wood, basic research in industrial technologies, high-temperature materials, metrology, agriculture, the environment, health and safety, and science and technology for development (EC Commission 1984 cited in Price, 1990:178). This first Framework Programme was given an overall budget of ECU 3750 million for the four-year period. Also in 1983, the rules governing Community R&D programmes were completed with new measures which aimed at ensuring a "European added value" and at the same time creating greater efficiency in the budgets and a new spirit within European academic and industrial establishments (Durand, 1991:51).

The discussions on the first Framework Programme took place at a time when the Commission was engaged in Round Table negotiations with some leading European electronic firms about the establishment of an effective programme in information technologies to enhance Europe's competitiveness in this sector.[5] Subsequently the Commission presented a proposal to the Council of Ministers on the formation of a European Strategic Programme for Research and Development in Information Technology (ESPRIT), in 1983, which was approved for 1984-88 as ESPRIT I and became part of the Framework Programmes. The launching of ESPRIT was focused on five main areas of research and development: advanced microelectronics, software technology, advanced information processing, office systems and computer-integrated manufacture (Harrop, 1989:97). ESPRIT, which was to become the model for subsequent programmes, had the following features: It

- was restricted to pre-competitive research;
- was based on co-funding by the Community and industry;
- involved firms, research institutes and universities in more than one EC country;
- provided the participants in any project with the freedom to apply the results of the project on a commercial basis;
- permitted access at this point to other ESPRIT participants;
- had a light and speedy grant-awarding process (see Laffan, 1992:99-100).

[5] The firms included Bull, CGE, Thomson from France; AEG, Nixdorf, Siemens from Germany; GEC, ICL, Plessey from the United Kingdom; Olivetti and Stet from Italy; and Philips from the Netherlands.

Therefore in ESPRIT the European Union has a leading example of regional co-operation and integration, which has been instrumental in organising and funding co-operative R&D programmes among firms located throughout Europe to increase European technological capability in the broad area of information technology (IT) (Nueño & Oosterveld 1986, cited in Malecki, 1991:195). Other programmes, such as EUREKA (European Research Co-ordinating Agency) and JESSI (Joint European Submicron Silicon), are intended to "make Europe's productive system in high technology sectors more competitive in the tough confrontation with the US and Japan" (Malecki, 1991:195).

The EUREKA multilateral research programme was launched in July 1985 through the initiative of the President of France, the late Francois Mitterand, with the aim of promoting European co-operation in industrial research or transnational R&D, not only among firms, but also between firms and universities, government agencies and research organisations (Onida & Malerba, 1989). EUREKA does not have a budget of its own and supports projects via national funding. Not all the projects are really industrial in nature; EUREKA also contains a series of target research initiatives of a social nature, particularly in the environmental field. The initiative involves 24 countries, including some in Central and Eastern Europe. After some initial problems the EUREKA projects and the Union's research projects are now being carried out with good co-ordination. The Commission is the 25th partner of EUREKA and the European Union participates in 35 EUREKA projects.

Following the first Framework the second Framework Programme, which was developed for 1987-91, was duly adopted and given an estimated budget of ECU 6480 million. The scope of fields for research was expanded to include medical research on Acquired Immune Deficiency Syndrome (AIDS), radiation protection and occupational medicine, pollution and climatology (greenhouse effect), pre-standardisation research (in order more easily to establish European norms and standards) and biotechnology (Price, 1990:179).

By 1995, after a decade of Framework Programmes, research support, including structural funds, had increased to nearly ECU5 million per year (European Commission, 1995). Table 7.1 illustrates the various Framework Programmes and the areas of research which have been of strategic importance and warranted European co-operation in the First Framework to the Fifth (current) as well as the future Sixth Framework. In fact, the EU's budgetary commitment to the current Fifth Framework Programme (1998-2002) is nearly 15 billion euros. On average the Union is spending over 3 billion euros per year on transnational research projects, which represents close to 5% of all the publicly funded civilian research undertaken in Europe, "but with huge impact, essentially on building transnational co-operation networks" (Mitsos, 2001). About 13 700 million euros of this amount are meant for the implementation of the European Community Programme section, and 1260 million euros for the EURATOM programme. The Fifth Framework has four Thematic and three Horizontal Programmes and Key Actions, which cover 23 areas of research identified as priorities in enhancing European competitiveness and the creation of employment. Since 1983 information technologies, through ESPRIT, have dominated, with a current percentage of 24% of the total of Fifth Framework budgetary allocation. Only the combined energy, environment and sustainable development programmes, which add up to 21%, come close to the IT disbursements.

TABLE 7.1: Funding and Research field of Support Framework Programmes

Framework Type	Period	Estimated Amount (ECU billion)	Thematic Programmes/ Some Areas of Research
Framework I	1984--1987	3.7	Information technologies; nuclear and non-nuclear energy; raw materials; recycling of industrial waste; wood; basic research in industrial technologies; high temperature materials; metrology; agriculture; environment; health and safety; science and technology for development.
Framework II	1987-1990	5.7	Information technologies; Acquired Immune Deficiency Syndrome (AIDS); radiation protection and occupational medicine; pollution and climatology; pre-standardisation research; biotechnology
Framework III	1990-1994	6.6	Information technologies and industrial and material technologies (enabling technologies); management of natural resources comprising environment; life sciences and energy; and management of intellectual resources consisting of human capital and mobility. (Trans-European networks between administrations, transport services, health care, flexible and distance learning, libraries, linguistic research and engineering, telematics systems for rural areas).
Framework IV	1994 -1998	13.2	Information technologies (15.8%); industrial and material technologies (13.9%); non-nuclear energy (8.1%); controlled thermonuclear fusion; telematics (6.8%) environment and climate (6.9%) training and mobility of researchers (6.0%)
Framework V	1998-2002	14.9	User-friendly information society (24%); quality of life and management of living resources (16%); competitive and sustainable growth; energy; environment and sustainable development (14%); energy; environment and sustainable development – EURATOM (7%); improving human research potential and the socio-economic knowledge base (7%); promoting innovation and the participation of SMEs (2%).
Framework VI	2002-2006	17.5 billion	Genomics and biotechnology for health; information society technologies; nanotechnology; intelligent materials and new production processes; aeronautics and space; food safety and health risks; sustainable development and global change; citizens and governance in the European knowledge-based society.

Sources: André, Fasella and Ruberti, 1998; http:/www.europa.eu.int/comm/research/fp4.html

Important to the Framework Programmes development process is the consultation on Policy formulation. In fact, there is often Europe-wide consultation on policy documents, besides the consultation within the various member states, within the structure of the EU. For example, the Green Paper on Innovation is a case in point where the opinions of the European

Parliament, the Economic and Social Committee and the Committee of the Regions were sought. These bodies emphasised in particular the significance of technology dissemination, the principle of subsidiarity, the role of economic operators and the social aspects of innovation (European Commission, 1997:25).

Alongside the internal consultations on the research programmes of the European Commission, there was the creation of external advisory bodies to help in the policy and direction of S&T within the EU. These bodies were CREST (Scientific and Technical Research Committee), which brought together senior national research officials, IRDAC (Industrial Research and Development Advisory Committee), which is made up of senior industrial mangers; and the European Science and Technology Assembly, at present consisting of around 60 personalities from different areas of public and private research. Both CREST and IRDAC, however, were dissolved and the Commission set up the European Research Forum (ERF) to continue with the efforts, making valuable contributions towards the building of the European Research Area.

Fundamental to building a strong, innovative and knowledge-based economy is the education and training programmes for student exchange within the EU, which have been introduced at various stages of the Community's development since the 1980s. For example, education and training programmes include ERASMUS (the European Community Action Scheme for the Mobility of University Students), which was the first programme, and ran from 1987-94 with a budget of US$440 million. It trained more than 300,000 undergraduates in all disciplines. The success of ERASMUS led to the launching of the second programme, Socrates (1995-1999), with funding of US$800 million to sponsor 700,000 students to train in other member states in all disciplines. The EU also started the Human Capital Mobility programme for postgraduate and postdoctoral exchanges to enable 3500 young researchers to train or work in laboratories outside their own countries at an estimated cost of $490 million between 1992-1994. The Training and Mobility of Researchers programmes, also for postgraduates, was launched from 1994-1998 with an amount of US$700 million which targeted 7000 postgraduates (Science, 1996:694). Equally important in training and researcher mobility programme is the Marie Curie fellowship and network programme under the Fifth Framework Programme. Also, the EU's contribution to the European Social Fund under various Community objectives and initiatives, such as Leonardo da Vinci, ADAPT and Emploi, are all attempts to help sustain the skills development of the Community. Besides these programmes, facilities are also being created for transnational secondments of young researchers and engineers to business (EC, 1997:28).

7.2.5 Evaluation and Lessons

The EU Treaty, with EURATOM, forms the basis for European research co-operation and also allows for the use of other policy instruments to support scientific and technological activities within the Union, besides the main Framework Programmes. As Herman (1996:79) puts it, the Treaty of Maastricht "brought within the EU's remit the objective of social cohesion between the member states and co-ordination of national policies for research and technological development". In order to achieve this objective, there has to be periodic and consistent evaluation of S&T policies and programmes to determine their impact on the socio-economic transformation of the European economy. Normally, the system of evaluation of the Framework Programmes involves annual monitoring and a five-yearly assessment of Programmes. So far, studies which have been conducted on the impact of the Framework Programmes on member states show that researchers profit from such collaboration by gaining access to complementary expertise and results, by the strengthening of European research and technological development links, as well as by obtaining extra funding. At the same time, it is felt that the Framework Programmes have contributed to creating a more stable, collaborative environment which, on a more positive note, has led to the formation of a genuine "European scientific Community" (Herman, 1996:79).

A more recent evaluation of the Framework Programmes by an Independent Expert Panel, which was commissioned by the European Commission in December 1999, affirms this. The report, which covers the performance of the Third, Fourth and early Fifth Framework Programmes over the period 1995-1999, was presented to Commissioner Busquin on 19 July 2000. The Panel note in their general assessment that "the Framework Programme has helped academic and industrial partners all across the EU to tackle problems collectively. It has also contributed to the training of researchers and the development of the European research infrastructure" (Independent Expert Panel report, 2000). Similarly, the Panel noted that it was satisfied with the achievements of the Third and Fourth Framework Programmes, as well as convinced of their effectiveness.

Annual monitoring through Independent Technical Audits has been part of the Framework Programmes. In some cases these have helped to redirect funds to other areas of research when projects already started have been found to be no longer feasible. For example, under the Advanced Communications Technologies and Services (ACTS) programme under the Fourth Framework Programme, the Independent Technical Audit each year led to 78% of projects supported redefining their work priorities and schedules at mid-term. About 4%-5% of projects were terminated, although by mutual agreement with the partners, in the light of the difficulties that had been highlighted. In this process the modification and the early termination of unpromising projects allowed over 18% of the ACTS Programme budget (about ECU 110 million) to be re-allocated to new work during the course of the Programme (European Commission, 1999). However, the Independent Expert Panel report noted that monitoring and evaluation should not be over-emphasised. That is, every effort must be made to avoid the danger of over-evaluating activities of RTD (research and technological development) and instead "more emphasis should be placed on demonstrating the relevance of the RTD efforts" (Independent Expert Panel report, 2000). Nevertheless, the above example indicates that resources are being used carefully for the development of S&T at the European Union and in helping the Union's competitiveness in the global market.

Furthermore, the institutionalised patterns of the research and development process provide structural dynamism in policy formulation and implementation, as well as the monitoring and evaluation. Through the various monitoring and evaluation reports and the work of the *ad hoc* advisory committees, the Commission is able to engage in effective transformation of the research and development landscape within the Union. The reviews and evaluations also allow the Commission to identify those new areas of research, under each of the past and present Framework Programmes, which should be prioritised. An example is the new research field of nanotechnology incorporated into the Sixth Framework Programme and allocated an estimated budget of 1300 million euros. This area of research is considered important because of the relevance of the nanotechnology sector in the global market, encompassing areas such as material sciences, precision engineering, electronics and biomedical applications. As the Commission's Sixth Framework Proposal puts it: "… lying at the frontier of quantum engineering, material technology and molecular biology, and one of the foreseeable hubs of the next industrial revolution, nanotechnologies are attracting considerable investment on the part of the EU's competitors (500 million dollars of public funding in 2001 in the United States, i.e. twice as much as current spending there and five times as much as Europe spends at present)" (European Commission, 2001). This also re-emphasises the point that the concerns, which led to the adoption of the First Framework

Programme nearly two decades ago, are still valid and help in the direction of the European Union's research and technological development programmes.

Viewing the past Framework Programmes in a positive light, the Independent Expert Panel Report (2000) made the following summarised recommendations for taking forward scientific and technological co-operation:

- maintaining the emphasis on social relevance and continuing to use Key Action as a way of focusing programmes;
- maintaining a strong emphasis on collaborative RTD projects supplemented by a variety of other actions;
- emphasising excellence and the participation of leading researchers;
- encouraging participants to propose "riskier" projects;
- enhancing measures encouraging the mobility of researchers within the EU and between the EU and elsewhere;
- retaining support for generic, competence-building RTD activities; and
- increasing the emphasis on the research needed to support other EU policies.

The mobility of researchers and training programmes within the EU and with other co-operation partners has been fundamental in establishing co-operation in S&T and even in the social sciences. These programmes have helped in promoting further networking among recipients of fellowships, as well as helping in the harmonisation of education and training processes within member states to the extent of achieving a certain level of European Dimension of research and training. As one commission's directorate on education and training noted, through the exchange programmes the EU suddenly realised "how much easier it is to shift goods, rather than people, around the single market" (Science, 1996:694), yet the movement of people is vital in promoting co-operation and integration. The programmes have assisted in improving intra-European training to a higher level than existed before 1987.

In a nutshell, the progress that has been made within the Framework Programmes would have been impossible but for the common realisation and understanding of the scientific and technological problems confronting the European Community, and now the European Union.

Especially the fact of the technology gap between it and the US and Japan dawned on the EU member states and that there was a need to tackle the technological problems in order to enhance Europe's competitiveness in order to provide employment and to maintain social cohesion. This also means that member states have to meet their Treaty obligations by making their financial contributions readily available. They also have to meet the Framework Programmes' demands as well as those of other policy instruments that require their commitment in moulding co-operation and integration in Europe under the EU Treaty. Often some project initiated under the Framework Programmes may not work, but without monitoring and evaluation it is impossible to ascertain what corrections should be made, hence evaluation has been an important part of the EU research and technological development processes. The current EU Treaty provided the European Commission with the basic tools for helping the transformation of European research and technological development through co-operation and co-ordination of programmes within the Union.

7.3 THE ASSOCIATION OF SOUTHEAST ASIAN NATIONS

7.3.1 Introduction

Since its formation in August 1967 the Association of South East Asian Nations (ASEAN) has been increasingly emerging as the South's success story of effective and efficient regional co-operation and integration, instituted along the lines of the European Union.[6] If this assertion is true, then discussion of ASEAN's S&T co-operation is useful for Africa's regional and sub-regional institutions to learn from ASEAN's experiences. Within ASEAN co-operation in S&T among the member countries falls under a broad heading: *functional co-operation* within the Bureau of Economic and Functional Co-operation. The activities of the Bureau cover S&T, the environment, culture and information, social development, drugs and narcotics control and the civil service. The basis of this co-operation was put in place in 1967 with the signing of the Bangkok Declaration with the following aims, among others:

> To accelerate the economic growth, social progress and cultural development in the region; to promote active collaboration and mutual assistance on matters of common interest in the economic, social, cultural, technical scientific and administrative fields; as well as to provide assistance to each other in the form of training and research facilities in the educational, professional, technical and administrative spheres.[7]

[6] There were five countries as founding members of ASEAN in 1967 (Indonesia, Malaysia, Philippines, Thailand and Singapore). Due to increases in membership, the Association now has 10 member countries. In addition to the original five, members now include Brunei, Cambodia, Lao PDR, Myammar and Viet Nam.
[7] ASEAN http://_www.asean.or.id/history

Notwithstanding this Declaration, however, S&T co-operation among ASEAN member countries in fact began in 1970, when the ASEAN Ministerial Conference established the ASEAN Permanent Committee on Science and Technology (Ali, 1995:135). Then in 1974 Terms of Reference for the ASEAN Permanent Committee on Science and Technology were formulated. However, Ali (1995) notes that the establishment of the ASEAN Committee on Science and Technology (COST) in 1978 actually marks the beginning of an effective institutionalisation of S&T co-operation within the organisation. (It was the Permanent Committee that was renamed COST, after restructuring of ASEAN's co-ordinating machinery). COST was to promote and accelerate the development of scientific and technological expertise and human resources as well as facilitate the transfer of technology from more advanced countries to ASEAN Member Countries.[8]

7.3.2 Institutional Policy Framework and Programmes

The overall institutional framework for ASEAN regional co-operation in S&T comprises four main components: (1) policy making; (2) programme formulation, management, co-ordination, evaluation, and monitoring; (3) project management, co-ordination, and implementation; and (4) co-ordination and support services. The S&T policies for regional co-operation are decided at a meeting of ASEAN Ministers for Science and Technology, which is usually held every three years, preferably to coincide with the marking of the ASEAN Science and Technology Week (Ali, 1995:142). For instance, at a meeting of the ASEAN Ministers for Science and Technology in 1983, guidelines for ASEAN S&T co-operation were formulated. These included defining the objectives of such co-operation; the principles, areas, and the mode of co-operation; as well as the mechanisms for the financing of ASEAN programmes in S&T (Ali, 1995:136).

As the main ASEAN body for regional co-operation in S&T, COST meets twice a year to review progress of projects, deliberate on new programmes and as well as to set strategic directions for implementation by its nine Sub-Committees. COST is chaired by way of rotation among the member countries. Since 1983, COST has become the main vehicle for the implementation of various projects and activities under the ASEAN Plan of Action on Science and Technology. The first Plan was for the period from 1983-1987, followed by a revised Plan in 1987, and then another one for 1989-1993. This Plan of Action on S&T was upgraded in 1994 and now represents the "strategic blueprint" for the implementation of

[8] ASEAN http://www.asean.or.id/history/ans_fnc2.htm

"ASEAN co-operation programmes that will support national and regional economic and social development initiatives into the next century" (see Teng-Zeng, 1999). Also under this Plan of Action, co-operation in S&T is to achieve the following set of objectives:

- A high level of intra-ASEAN co-operation in S&T which is synergistic and self-sustaining and has the active participation of the private sector;
- A network of S&T infrastructures and programmes for the public and private sectors for human resource development;
- An economically-beneficial institution-industry technology transfer;
- An enhanced state of public awareness of the importance of S&T to ASEAN's economic development; and
- An expanded S&T co-operation with the international community.[9]

These policy orientations were reinforced at the Second ASEAN Informal Summit held in Kuala Lumpur on 15 December 1997, where an ASEAN Vision 2020 was adopted. In order to implement this long-term vision, action plans are being drawn up to realise the Vision. The Ha Noi Plan of Action (HPA) is therefore seen as the first in a series of such plans of action building up to the realisation of the goals of the Vision. The HPA has a six-year time-frame covering the period from 1999 to 2004. The progress of its implementation will be reviewed every three years to coincide with the ASEAN Summit Meetings. The HPA duly includes a section on S&T, which aims at promoting S&T development, broadly as a reaffirmation of ASEAN's commitments to closer integration which are geared towards consolidating and strengthening the economic fundamentals of the member states. Hence the Plan *inter alia* requires ASEAN to:

- Establish the ASEAN Information Infrastructures;
- Develop the Information Content of the ASEAN Information Infrastructure by 2004;
- Establish Networks of Science and Technology Centres of Excellence and Academic Institutions by 2001;
- Intensify Research and Development (R&D) in Applications of Strategic and Enabling Technologies;

[9] ASEAN http://www.asean.or.id/history/ans_fnc2.htm)

- Establish a Technology Scan Mechanism and Institutionalise a System of Science and Technology Indicators by 2004;
- Develop Innovative Systems for Programme Management and Revenue Generation to support ASEAN Science and Technology;
- Promote greater public and private sector collaboration in science and technology, particularly in information technology;
- Undertake studies on the evolution of new working conditions and living environments resulting from the widespread use of information technology by 2001.[10]

Furthermore, within ASEAN scientific and technological co-operation is organised around eight broad programme themes: food science and technology, biotechnology, microelectronics and information technology, material sciences and technology, non-conventional energy research, meteorology and geophysics, and infrastructure and resources development, which are among the prioritised areas under the ASEAN S&T Strategic Plan that correspond to the eight sub-committees of COST, namely:

1. Sub-Committee on Food Science and Technology;
2. Sub-Committee on Biotechnology;
3. Sub-Committee on Microelectronics and Information Technology;
4. Sub-Committee on Material Science and Technology;
5. Sub-Committee on Non-conventional Energy Research;
6. Sub-Committee on Marine Sciences;
7. Sub-Committee on Meteorology and Geophysics; and
8. Sub-Committee on Science and Technology Infrastructure and Resources Development (for details see Ali, 1995:138-141).

A ninth programme, space technology applications, has been added – bringing the number of Sub-Committees to nine. Each of the Sub-Committees is responsible for the detailed design and implementation of the sub-programme area. For example, Table 7.2 indicates the programme of the Sub-Committee on Biotechnology on building a region-wide, effective and efficient capacity to promote industrial resourcefulness.

[10] ASEAN, Ha Noi Plan of Action. http://www.aseansec.org/summit/6th/prg_hpoa.htm

TABLE 7.2: Sub-Committee on Biotechnology

No	Project Title	Project Brief	Remarks
1	ASEAN-India Co-operation in Plant Biotechnology for Crop Improvement and Better Utilisation of Natural Resources: Plant Tissue Culture	***Objectives***: To establish appropriate methods for stable transformation of selected crops with DNA constructs harbouring genes for resistance towards the most important insects and diseases; to identify priority endangered plant species of high medicinal value. ***Achievements expected***: Strengthening of research capacity and HRD in plant molecular biology and plant genetic engineering in participating countries & setting up of in-vitro conservation activities.	***Current status***: on-going project
11	Human Resource Development Programme in Biotechnology for CLMV: Short-term Training Fellowship	***Objectives***: 1. To deliver an on-the job training programme at BIOTEC, Thailand, for CLMV in the areas of food biotechnology, plant cell technology and microbial taxonomy and culture collection management. 2. To establish linkage and networking of research institutes and universities.	***Current status***: on-going project
2	ASEAN-India Co-operation in Animal Biotechnology: Embryo Transfer Technology	***Objectives***: To improve the technique of embryo transfer technology in ASEAN countries through collaborative research and training with Indian scientists and experts. ***Achievements expected***: Exchange of Indian scientists with Indonesia, Malaysia, Thailand and Vietnam, with at least 20-30 staff trained in each country, and training of at least two ASEAN staff from each ASEAN country.	***Current status***: pending project
3	ASEAN-Canada Biotechnology Information Network (ACBIN)	***Objectives***: The project aims to establish the infrastructure for a regional network of selected organisations in ASEAN Member Countries, which would be capable of collecting, processing and disseminating useful information, co-ordinating training and adaptive research programmes on biotechnology to relevant public and private sector researchers, manufacturers and entrepreneurs to maximise their activities.	***Current status***: pending project
No	**Project Title**	**Project Brief**	**Remarks**
4	ASEAN-New Zealand Co-operation in Biotechnology:	***Objectives***: to study the status of biotechnology research in each ASEAN member country and determine the area of biotechnology co-operation with NZ.	***Current status***: pending project
5	Sustainable Development and Utilisation of Tropical Rainforest Plants of Indonesia, Malaysia, Philippines, Thailand and Vietnam – Chemical Biological Prospecting of the Plants	***Objectives***: To strengthen national capabilities for the chemical prospecting of about 1,000 tropical rainforest plants in order to produce useful biologically active natural products and provide data to conserve biodiversity by establishing inter-institutional linkages and multi-disciplinary teams.	***Current status***: pending project for reformulation by UNESCO.

No	Project Title	Project Brief	Remarks
6	Biotechnology Strategies: Development of New and Improved Biocontrol Agents for Pest and Insect Control in South East Asia (Reformulated to: Biotechnology for Biocontrol: HR Development, as for SCB – 24, May 2001)	***Objectives***: To develop specific Biocontrol agents relevant to pest and disease problems in ASEAN using genetic manipulation and cell culture techniques; to improve skills of ASEAN scientists in molecular biotechnology and bioprocessing engineering for the development of biocontrol agents; to co-ordinate and support R&D and training activities in participating ASEAN countries; and to enhance dissemination of relevant information to end users, and explore possibilities for commercialisation; and networking through scientific meetings and interaction with farmers and the public.	***Current status***: pending project for appraisal
7	ASEAN-India Cooperation on Bioinformatics Network	***Objectives***:	***Current status***: for reformulation
8	Strengthening Capability of ASEAN in Biosafety: Scientific, Technical, Institutional and Legal Aspects	***Objectives***: To strengthen biosafety guidelines for R&D and commercialisation of biotechnology products; to set in place/enhance the legal, regulatory & institutional frameworks for biosafety that are in line with accepted international practice, but take into account the trade, economic, social, cultural, ethical, environmental & biodiversity concerns of ASEAN member countries.	***Current status***: pending project
9	Publication and Translation of a Book on "Transgenic Cotton"	***Objectives***: The book, translated into English, published by the Chinese Academy of Agricultural Sciences (CAAS), would serve as comprehensive reference for ASEAN scientists in undertaking research on plant genetic engineering. Success criteria: publication and distribution of the book to AMCs and China.	***Current status***: endorsed by Project Appraisal Committee, subject to the provision of detailed information on to whom the ASEAN Secretariat will distribute the publication.

No	Project Title	Project Brief	Remarks
10	Agricultural Biotechnology Training for Cambodia, Lao PDR, Myanmar and Brunei Darussalam	***Objectives***: 1. To train CLM and Brunei Darussalam in strengthening manpower capacity of their scientists in biotechnological methods appropriate for in the areas of: a) cell and tissue culture techniques related to plant improvement and mass micropropagation. b) fermentation techniques such as production of enzymes, mass propagation of transformed hairy roots and cell culture for secondary metabolite production 2. to help strengthen the establishment of an ASEAN Scientific network in the field of biotechnology related to plant tissue culture ant fermentation technology, which would further enhance joint regional R&D collaboration in the future.	***Current status***: approved by ASC
12	Policy Option and S&T Capability Building Concerning Genetic Modified Organisms for Member Countries of ASEAN	***Objective***: To promote co-operation among ASEAN countries on policy formulation, implementation and monitoring in the field of GM foods through the broad participation of all stakeholders.	***Current status***: new project proposal
		New Project Proposal	
	ASEAN-China Project Proposal for Transgenic Rice	N/A	***Current Status:*** new project proposal

Source: ASEAN Secretariat.

Similarly, during the 39th Meeting of ASEAN COST held from 10-12 May 2000 at Vientiane in Lao PDR, preparations were made for a Plan of Action for ASEAN S&T Co-operation for the period 2001-2004. The Plan of Action will take into account the Ministerial decision adopting as a long-term goal the establishment of an ASEAN Science and Technology Community for Innovation, Competitiveness and Knowledge (ASTICK) for the 21st Century. It will also consider fast-track programmes on human resource development, information technology development, institutional networking and promotion of public awareness of science and technology that require urgent implementation. To make such a Plan meaningful, the nine Sub-Committees of COST will also review their objectives and priorities to incorporate them into the Plan.[11]

[11] "ASEAN science and technology co-operation moves forward". Joint Press Release 39th Meeting of the ASEAN Committee on Science and Technology (COST) 10-12 May 2000, Vientiane. http://www.aseansec.org/view.asp?file=/function/prcost39.hmt 11/15/2001.

7.3.3 Funding S&T Programmes and Activities

Ali (1995) argues that S&T regional co-operation, as promoted by ASEAN COST, is to a large extent dependent on external financial contributions from ASEAN's dialogue partners. The donors include Australia, Canada, New Zealand, Japan, the United States, the European Union and, as a late addition, the republic of South Korea, and the UNDP for implementation.[12] The UNDP, for example, provided under its ASEAN-UNDP Sub-regional Programme for the fifth Cycle (1992-1996), or ASP-5, technical assistance totalling US$5.8 million in five sub-programmes. Science and technology was one of the areas and assistance was provided for the operationalisation of the 1994 ASEAN Plan of Action on Science and Technology; ASEAN S&T Indicators and Information Systems; Public and Private Collaboration in Regional Science and Technology and in Technology and the Environment.[13] However, this means that such funding is dependent on the vagaries of the economies of ASEAN's dialogue partners and therefore the changes in their research and development agendas. It also means that there cannot be any long-term programme and research interest sustainable for ASEAN.

Out of these imperatives arose the idea of establishing an ASEAN Science Fund. Thus, in 1989 ASEAN took a step towards the establishment of the ASEAN Science Fund with initial seed contribution of US$50,000.00 from each ASEAN member state. Then, at its 38th meeting in Singapore on 29 October 1999, COST concluded an agreement to raise US$10 million among its member countries to seed a project in science and technology. Also, at the ASEAN Science and Technology Ministers meeting in 1999 an agreement was reached to raise the threshold contribution or target to US$1 million per member country. The member countries were informed that this amount was payable over a period of 10 years, with 1999 as the starting year. Furthermore, in November 2000 it was reported at the ASEAN COST 40th

[12] The idea of developing external relations with dialogue partners, mostly ASEAN major trading partners, started with a resolution in 1976 at the First Meeting of the ASEAN Heads of Government. This was followed by formally established, full dialogue relations with Australia, Japan, New Zealand and the UNDP in 1976 (the UNDP is the largest single multilateral aid organisation and the only non-governmental Dialogue Partner of ASEAN); the United States of America in 1977; the EU in 1980; Canada in 1981; Republic of Korea in 1991. India started as a Sectoral Dialogue Partner of ASEAN in 1993 but became a full Dialogue Partner in 1995. China and Russia began consultative relations with ASEAN in 1991 and were accorded Dialogue Partnership in 1996. Currently, Pakistan has had established Sectoral Dialogue relations with ASEAN since 1997 (http:www.asean.or.id/history/asn_ext3.htm).

[13] "ASEAN Co-operation and Dialogue Relations" (http:www.asean.or.id/history/asn_ext3.htm).

meeting held at Chiang Rai, Thailand, that member states were meeting their annual contributions towards the creation of the ASEAN Science fund as promised.[14]

Besides the Science Fund, ASEAN also established the ASEAN Fund in 1994 with contributions of US$1 million from each member state. An initial amount of US$6 million consists of two main accounts: the Seed Fund Account and the Projects Fund Account. The Seed Fund is made up of 80 percent (US$4.8 million) and the Project Fund consists of the remaining 20 percent (US$1.2 million). Usually, the Seed Fund is invested to realise income for the fund while the Project Fund provides financing for projects. Arrangements are made that at least half of the annual income accruing from the Seed Fund is ploughed back into the Seed Fund, while the balance accrues to the Project Fund (ASEAN, 1995:18).

Thus the ASEAN Fund may be utilised for projects which meet all of the following criteria: the projects must promote ASEAN co-operation or the ASEAN perspective, which is consistent with the ASEAN Summit decision; the projects must be of a confidential or strategic nature – this includes activities which may lead to the formulation of an ASEAN stand or position on issues of common interest to member countries, those which involve the acquisition or processing of strategic information, the acquisition of applied technologies, joint marketing studies or approaches, as well as promotional activities. Above all, if such projects could not qualify for funding under the Dialogue Partner facilities or could only be partially supported by Dialogue Partner facilities (ASEAN, 1995:18), ASEAN has also developed mechanisms for cost-sharing on S&T programmes.

7.3.4 Evaluation and Lessons

Co-operation in S&T is considered as one of the most important areas in the ASEAN region. The aim is to equip the region's human resources with knowledge to respond to the new challenges of economic modernisation and globalisation, as well as to strengthen the regional S&T base for greater economic competitiveness. In the light of this ASEAN sees three main challenges facing the S&T sector in fulfilling this as co-operation, integration and competitiveness:

a) To design programmes that will promote the quick integration of the new member countries into the mainstream of ASEAN S&T co-operation;

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[14] ASEAN COST http://www.aseansec.org/view.asp?file=function/prcost40.htm

b) To assert S&T's wider role in the entire development process; and

c) To accelerate the pace of S&T development by improving project development and implementation strategies and by ensuring more predictable financing of projects (ASEAN, 2000:59).

The first challenge stems from the fact that the scientific and technological resources (both human and material) of the various ASEAN member states are not at the same level of strength. Therefore the organisation of special seminars for the new members of the ASEAN has been part of the overall strategy within which to bring new members into line with scientific and technological standards for effective co-operation and development within the region. Individual member states with relevant scientific and technological capability are taking the initiative in assisting those still disadvantaged. For example, Singapore, Indonesia and Thailand agreed in May 2001 to organise and support the new member countries of the organisation by instituting training programmes for Cambodia, Lao PDR, Myammar and Viet Nam. The training programme areas include food microbiology, drying technology for agricultural products, biotechnology, application of information technology in hydrology, and technology management (see Table 7.2 above).

Programme implementation has been part of the overall strategy in ensuring that S&T capability in the ASEAN region is built up to promote economic competitiveness and integration. Therefore the various Sub-Committees of COST, which are responsible for the actual management, co-ordination and implementation of regional projects, have to be effective and efficient. For example, in 1997 there was a total number of 55 projects in food science and technology, meteorology and geophysics, microelectronics and information technology, material science and technology, biotechnology, non-conventional energy research, marine sciences, and science and technology infrastructure resources development, of which three were completed, 21 on-going, 24 pending; four being new projects and three were to be dropped.[15] The number of programmes remaining pending because of a lack of funds is a problem. For example, the establishment of ASEAN "Networks of Science and Technology Centres of Excellence and Academic Institutions by 2001" is one of the programmes under the Ha Noi Plan of Action. However, not much progress has been made, except that the Committee on S&T Infrastructure and Resources Development has planned

[15] COST 1998. Joint Press Release on the 35th meeting of the ASEAN Committee on Science and Technology. Manila, 30 March-3 April 1998. http://www.aseansec.org/view.asp?file=/function/prcost35.htm

for a programme called the "Networking of Science and Technology Centres of Excellence and Academic Institutions, Phase 1: Industrial Research Institutes", which is also still pending due to the lack of funds. The number of pending projects, which stands at 24, therefore indicates how far ASEAN still has to go in order to implement programmes that will be more sustainable.

To meet these strong challenges, a review of COST's programmes and priorities was required in order to make its operations more effective. Therefore the issue of the transformation of ideas and programmes is an integral part of its programme. As part of the growing importance attached to S&T, COST has organised the Asian Science and Technology Week (ASTW) every three years since 1987 to help popularise S&T within the region. During the ASTW celebrations the following awards are given: ASEAN Young Scientist and Technologist Award, ASEAN Outstanding Scientist and Technologist Award, and the ASEAN Science and Technology Meritorious Award. Besides this, ASEAN has also restructured its Secretariat and created a new ASEAN Co-operation Unit (ACU), which is now responsible for all aspects of project appraisal and funding management, in close co-operation with its Dialogue partners.

The weaknesses in regional programmes prompted Roger Posadas (1999) to argue in a recent article in the journal of *Science, Technology and Society*) that, while building their individual NSI, ASEAN countries should adopt a regional approach through:

a) adopting and implementing an integrated ASEAN system of S&T exchange, collaboration and complementation;

b) undertaking, under the auspices of ASEAN, certain strategic region-wide mission-oriented R&D programmes (similar to EU's EUREKA, ESPRIT and EUCLIP); and

c) establishing a network of regional R&D institutes and regional S&T centres of excellence, as well as a world-class ASEAN university of science and technology.

Posadas's argument is that " South-East Asia could be more assured of a more viable S&T future if the region would collectively pursue technoregionalism than if the countries try to pursue either technoliberalism or technonationalism separately (Posadas, 1999:129). As we have already noted in Chapter 4, technoregionalism is "the pursuit of scientific and technological co-operation and networking within a certain region". In the case of South-East

Asia technoregionalism can be construed in the restricted sense of ASEAN S&T co-operation or, in the broader sense, of South-South co-operation, not only within ASEAN, but also within neighbouring regions like South Asia, East Asia and Central Asia.

Totally unlike Africa, where there are very few national efforts, which could have long-running impact in promoting greater S&T co-operation, the efforts among the ASEAN countries are very effective. Individual member states are pursuing the development of strong S&T infrastructure and human resource development. For example, in 1998 the Philippines contracted a US$85 million programme loan funded by the World Bank to upgrade facilities, including 110 new science laboratory buildings for selected high schools and new equipment for universities as well as support for 4000 science, engineering, and science education graduate students. Thailand also secured funding from several sources for major reforms of higher education that included boosting science and engineering enrolments. This loan was made up of a US$143 million World Bank loan to equip science and engineering laboratories together with a US$14 million grant from Australia to improve management practices and to help update curricula and teaching methods. Similarly, Indonesia attracted the World Bank funding of cluster of programmes to improve the links between education and research. These include the Development of Undergraduate Education aimed at 17 second-tier Indonesian universities; the Quality in Undergraduate Education for the top-tier universities and, lastly, Unifying Research and Graduate Education programme, a five-year multifaceted effort aimed at beefing up graduate education (Jeffrey and Dennis, 1998:1469-70). It is such strong national commitments, coupled with good economic growth in the past within the region, that have helped ASEAN countries to become worthy recipients of World Bank lending for S&T activities in the past.

7.4 GENERAL CONCLUSION

The discussion above shows that co-operation in S&T is firmly placed within the socio-economic development programmes in the EU and ASEAN, but even more strongly in the EU. The Treaty provisions of both institutions are a very important source of instruments for the promotion of scientific and technological co-operation among member states. The provisions of the treaties are, however, not a sufficient guarantee for promoting scientific co-operation and there has therefore been a need for the creation of an institutional framework within them. The European Commission and especially the Commissioner for Research and the Directorate-General for Research are basically responsible for the broad scientific and technological research and development programmes within the EU. However, given the broad nature of S&T, they work closely with the other Commissioners, e.g. for Industry and Agriculture, and their directorates and other relevant bodies or institutions within the framework of the Union to formulate research policies and help in identifying European priority areas of research, particularly in the Framework Programmes. Through the Framework Programmes the collective awareness of and attention to regional science and technology programming is now institutionalised in the European Union to enhance co-operation and integration and European international competitiveness.

Similarly, providing a strong S&T organisational structure was a pre-occupation of the authors of ASEAN S&T co-operation long before they started with regional S&T programmes. Through COST and its nine Sub-Committees, which represent the prioritised areas of research required for building a strong ASEAN economy as well as international competitiveness, ASEAN now has a sound foundation for scientific co-operation. However, a major weakness of ASEAN is that regional S&T programmes are basically supported by external donor funding or, to put it another way, their Dialogue Partners. However, ASEAN has recognised this imperative and has responded by instituting an ASEAN Science Fund with a target of raising US$10 million as seed money for regional programmes. Development of the required scientific and technological infrastructure and necessary skills is a part of the regional approach.

Programme themes, including food science and technology, biotechnology, microelectronics and information technology, material sciences and technology, non-conventional energy research, meteorology and geophysics, and infrastructure and resources development are among the prioritised areas of research and technological development in both the EU and ASEAN, except that the EU is now moving into an additional field, nanotechnology, as one of the areas for European research. Building a knowledge economy anchored in instruments of knowledge-based development is therefore the driving force currently encouraging their scientific and technological co-operation in order to promote regional competitiveness as well as sustainable socio-economic transformation and development. The benefits of technoregionalism or technological alliances in addressing individual national scientific and technological weaknesses are motivational factors.

CHAPTER EIGHT

CONCLUSIONS AND RECOMMENDATIONS

8.1 CONCLUSION

What this study has done is to highlight, first and foremost, the scientific and technological gap that exists between Africa and rest of the world. However, most researchers and policy-makers working on the socio-economic development of Africa tend to complain about the general lack of credible sources of data on science and technology indicators and how difficult it is to collect reliable facts. This lack of credible data creates problems for analysts; where such data exist at all, they are often many years out of date and do not reflect the current situation. These problems are often highlighted in the UNDP's Human Development Report as well as the various annual reports by UNESCO, the World Bank and other institutions. Therefore, in the introductory chapter as well as in the rest of this study a special effort has been made to use the most recent available data. In terms of science and technology indicators for both input and output, Africa still falls far below most other regions. The low level of scientific and technological skills available for research and development, the low level of investment in research and development revealed by expenditure in this area as a ratio of GNP, and the low level of S&T production and innovative activities are among some of the major problems, and therefore the fundamental weaknesses, of S&T development in Africa.

Poverty, hunger and disease in Africa are exemplified by the horrors of the human immuno-deficiency virus/acquired immune deficiency syndrome (HIV/AIDS) pandemic and the continuous threat of malaria, trypanosomiasis and onchocerciasis, among others. Given the enormous development challenges facing the entire African continent, the need for tackling these issues through scientific and technological progress, involving capacity building in both basic and applied research and development, cannot be overemphasised. Increasingly, the development tasks are such that no country in Africa is capable of performing them alone. Hence a number of authors and researchers as well as some policy-makers have called for regional co-operation in S&T in order to facilitate and find solutions to some (if not all) the problems which Africa faces in the current global political economy. This is why the *New Partnership for Africa's Development* (NEPAD) initiative makes regional and sub-regional co-operation in S&T a priority. We also know that development problems and policies are influenced to a great extent by the development paradigm that a particular state or institution adopts. It therefore became apparent that we should explore the role that development theories play in the development of S&T, given the proliferation of international development institutions during the post-World War II period. This *problematique* became a matter of concern in Chapter 2 of the study.

That chapter examined the extent to which development theories explained the role of S&T in the socio-economic development and the transformation of developing countries. Amongst the theories are modernisation, dependency and structuralism, knowledge-based development and post-development. Our argument is that many of these development theories, whether considered as neoclassical, Marxist, neo-Marxist or in any other form, do in fact recognise the importance of science and technology in the development process. However, the way in which policy-makers and implementation bodies encourage the pursuit of S&T is influenced by the particular development ideology they espouse. Since ideology determines strategy, while political differences over the years have influenced the kind of technology that developed countries have transferred to their counterparts in the developing world. Our main theoretical stand lies in the application of a knowledge-based development (KBD) paradigm in the policy formulation and programmes in Africa, where the necessary infrastructure, skill and experience are lacking and strategic choices have to be made in deciding which fields of scientific endeavour are critical to the continent's development.

However, none of the existing theoretical frameworks is adequate to address all the development problems confronting the South in general, and Africa in particular. For instance, we advocate a knowledge-based development paradigm (KBD), which entails the building of the appropriate infrastructure, skills and experience and knowledge. However, structural analyses will be required to help us identify the extent and causes of global imbalances in terms of the scientific and technological gap between developed and developing countries, which is of paramount importance. The importance of KBD is that it brings knowledge to the forefront of the development debate. As the channels through which resources are allocated to developing countries, international and regional institutions (both governmental and non-governmental) have crucial roles to play in this debate. Although these institutions are not sovereign states and do not assume supranational authority and authoritative allocation of values and resources, we looked at the roles of some of these institutions in policy terms to determine whether the development ideology subscribed to accords any importance to science and technology in the development process, since we wanted to evaluate some of their programmes. Moreover, we believe that international and regional institutions have a fundamental role to play in the future development of science and technology in Africa, given the under-resourced nature and small size of most of its countries.

Of interest in our theoretical discussion is those post-development theorists who provide a general critique of development, as well as launching an attack on, or an analysis of, modern science and technology and their role in socio-economic development and transformation. The prospects for the application of science and technology for development, as advocated in our discussion of the knowledge-based development theory, is challenged by some post-developmentalists. One of their main articles of faith is that modern science and technology give rise to alien conceptual categories that are injurious to poor people in the developing world and their local knowledge. For instance, we noted Claude Alvares's (1992a) point: "I was born into a culture that continues to exercise greater influence and power over behaviour than modern science does, or will ever do. If *that* were properly understood, then this obituary would not appear either scandalous or scurrilous. Every culture enjoins its members' respect for certain entities. Modern science does not find a place in *our* pantheon".

In fact, post-development theorists are also very quick to point out the devastating effects of modern S&T on society and the environment. Principal among these negative impacts are nuclear disasters (e.g. Chernobyl), weapons of mass destruction (both biological and chemical) which are a constant threat to the very existence of humanity, whose course modern S&T is seeking to advance. According to Sachs (1992), "for more than a century technology carried the promise of redeeming the human condition from sweat, toil and tears. Today, especially in the rich countries, it is everybody's best-kept secret that this hope is nothing more than a flight of fancy". These shortcomings are useful reminders of the negatives impact that S&T can have on society. Therefore, it is appropriate for us to raise this matter and to recognise the negative impact of modern science and technology on socio-economic development and transformation, but we do not have to overemphasise them. That would be a recipe for disaster, since the socio-economic benefits of S&T outweigh their negative impact. Hence KBD should be pursued whilst taking cognisance of, and minimising, the disadvantages in its application. Post-development theorists also stress the importance of indigenous knowledge (IK) to local and regional development and thus a combination of these insights with KDB in an eclectic approach by international and regional institutions in the development of S&T will be very useful.

However, the criteria for assessment of the institutions were derived from the knowledge-based development theory in which the INEXSK (Infrastructure, Experience, Skills, Knowledge) approach was used broadly. The way that the international, regional as well as sub-regional institutions and programmes helped in the development of infrastructure and skills capacity and the specific knowledge areas especially agriculture, biotechology and telecommuncations was discussed.

Before being able to deal with the role of international institutions in the development of S&T in Africa, we had to consider the history of the development of science and the institutionalisation of scientific and technological co-operation in Africa; this was done in Chapter 3. From this discussion an outline is drawn of the stages of the development of S&T in Africa. In all, four phases were identified: the pre-colonial, colonial, national and the post-national. The main significance of this taxonomy lies in the discussion of the pre-colonial and the post-national phases. This is because most scholarly work on science and technology in Africa, particularly in economics and politics, focuses on the colonial phase and the subsequent developments, either without any consideration of the pre-colonial phase, or leaving this to archaeologists and historians. However, recent discussions on indigenous knowledge (IK) have brought to the forefront some of the importance of the pre-colonial S&T. Others dwell in their analyses on the national phase, although the trend is increasingly towards international or transnational scientific activities.

An interest in agriculture, in particular those crops mainly for export, in mineral exploration and exploitation, and developments in tropical medicine marked the colonial phase. The colonial period, furthermore, saw the genesis of inter-territorial co-operation and therefore the emergence of regional institutions in the various territories comprising the British, French, Portuguese and Belgian colonies in Africa. The differences in style of the various colonial administrative systems influenced the patterns of scientific and technological development in the colonies. However, the settler-colonial status of the Union of South Africa and Southern Rhodesia present a different dimension. Hence, these two countries had well-developed scientific infrastructure and were able to play a meaningful role in inter-colonial co-operation in science and technology. This saw South Africa becoming the first country to host the African Regional Conference on Science in 1949 in the aftermath of which the Commission for Technical Co-operation in Africa South of the Sahara and the Scientific Council for Africa South of the Sahara were established.

In most of the colonial territories, however, the advent of independence witnessed either the collapse or the nationalisation or Africanisation by the newly independent states of the regional inter-territorial institutions at the sub-regional level. At the continental level, following the formation of the OAU in 1963, the CCTA and the CSA were adopted in 1965 as regional organs under the OAU to promote scientific and technological co-operation and development. However, the national and regional efforts in the pursuit of S&T in the 1960s and 1970s, as well as during the 1980s, did not achieve the desired results. Most African countries, besides, had missed out on the opportunities of the 1950s and 1960s, when the establishment of bilateral as well as multilateral institutions, both within and outside the United Nations system, helped to promote new forms of S&T co-operation. By the mid-1960s, as the African countries became established, the international political landscape had begun changing due to the Cold War (Anandakrishnan, 1998). Therefore, notwithstanding the subsequent development of national research communities in many African countries, Africa remains the region of the world most penetrated by, and dependent upon, external scientific and technical expertise, resources and research activities.

Delineating the phases of the development of S&T in Africa is not as straightforward as it might seem at first glance. While it may be possible to isolate the colonial era, the national and post-national phases are more of a problem. However, programme formulation and implementation serve as guiding principles to help us differentiate the various phases.

The lack of progressive development of S&T at the national and regional levels has meant that the competitiveness of Africa, as well as its contribution to world science, has deteriorated. Amidst this downward trend there have been renewed calls for regional co-operation in S&T by both international and regional institutions, which makes imperative an evaluation of the roles of these institutions in facilitating co-operation. This is because the success in generating knowledge for development will depend on the extent to which these international and regional institutions can help transform the continent through their programmes to alleviate, hunger, poverty and disease. Meanwhile in the post-national phase globally there is increasing participation by the private sector in scientific and technological research and development, whether in agriculture or industry. An enormous task now faces African countries since, in spite of trade liberalisation and increasing privatisation of state-owned enterprises, private sector investments in R&D are still very low compared to those in developed countries and even in Asia and Latin America. Hence, Africa's reliance on international governmental institutions and their programmes on S&T in Africa.

There has been a fundamental recognition since the establishment of the United Nations Education Scientific and Cultural Organisation of the importance of science and technology for development. UNESCO has been constantly influential at various different periods to a greater or lesser extent in drawing the attention of the international development community to this fact. The World Bank, since it first began lending to developing countries after the reconstruction of post-World War II Europe, also began taking a keen interest in S&T issues in the early 1970s during the McNamara presidency. Similarly, the Economic Commission for Africa has also been involved in assisting Africa to set up some S&T institutions for capacity building, as well as in the organisation of workshops, seminars and conferences in which UNESCO and the World Bank have also been participants.

An important finding is that, while all the three institutions are autonomous, co-operative agreements are often negotiated among them. For example, the World Bank has had co-operative arrangements with UNESCO, which were often used to the Bank's advantage. During the 1970 fiscal year eight of the Bank's projects which were approved had been identified or prepared with the help of UNESCO. UNESCO staff members also participated in eleven Bank missions during that year for preliminary identification of education projects, before their agreement was terminated in 1986. This agreement is now being rebuilt in a more active way. It is unclear how this new agreement between UNESCO and the World Bank will help promote scientific and technological development in Africa and the developing regions in general.

All three institutions argue that they support science and technology, but their levels of support differ. However, all their programme support for S&T at the regional and sub-regional level is quite limited, especially in the development of scientific and technological infrastructure, except the ECA. On the one hand, UNESCO's support for infrastructure development has mostly been at the individual state-level in Africa. Likewise, the World Bank programmes support has been at the national level until quite recently, when it has been involved in trying to establish the Forum for Agricultural Research in Africa (FARA) in Africa since the SPAAR is ending. On the other hand, the ECA took the initiative in the 1970s in helping to establish regional institutions in Africa to promote techno-regionalism. However, as Adubifa (2001) argues:

> The respective mandates of these institutions were unrealistic with respect to available funding, staffing and operating facilities. Beyond initial funding, the member states gave little attention to science and technology, especially as their national economies took an expected downturn. The institution-building efforts also took on political dimension by which the management, staffing, service conditions, and international status of the institutions were to be politically negotiated. Without adequate core funding most of the institutions could not be sustained, and their skilled professional staff departed. This quickly led to loss of project funding from donors.

These problems led to the ECA's study for rationalisation and restructuring of these regional institutions in the 1990s. The implementation of the outcome of the study has, however, been problematic because of the political differences among the hosts of the affected institutions due to be merged. An example of this is the proposed merger of the ARCT and ARCEDEM. Thus these institutions have been left barely effective as regional engines for the scientific and technological development of the continent.

Reliance on extra-budgetary sources also compounds the difficulties involved in the development of programmes. This has created extensive donor dependence on funding from these international institutions of programmes in Africa. UNESCO's ANSTI programme is impossible without the active support of the German government through GTZ. The bulk of the funds supporting the World Bank's SPAAR programme does not come from the Bank. Besides, the use of funds for seminars, meetings, conferences and symposia is common among all three institutions. The irony here is that after these meetings and conferences nothing much is left (or forthcoming) for the actual development of scientific and technological capacity in Africa, or for its development and transformation.

Together the African Development Bank and the OAU are the leading multilateral institutions with a continental purview in Africa, and created by African countries. The charters establishing both institutions give great importance to regional co-operation and integration for development and transformation. The two institutions do not operate in isolation; they have signed a number of mutual agreements as well as agreements with other international development institutions. The AfDB, for example, signed a co-operative agreement with UNESCO in 1968 to help in project identification, preparation of joint operations and financing of projects. The AfDB also signed a co-operative agreement with the World Bank in 1967. This agreement made provision for technical co-operation, exchange of information, conduct of joint missions, co-financing of projects, harmonisation of operational procedures and methods and the training of AfDB staff. Subsequent to this agreement the World Bank offered a number of training opportunities to the AfDB's staff in both Washington and Abidjan and co-financed a good number of projects with the AfDB Group. For instance, under ADF III, 5 per cent of ADF resources were to be devoted to technical assistance and the bank itself decided to increase its loan allocation for engineering studies during the bank's operational programme for the period 1982-1986.

However, the AfDB has not been able to meet its own set targets for multinational programme lending in support of regional co-operation and integration in Africa over the years. While the AfDB Group's new policy for regional co-operation and integration has recommitted the AfDB Group to support such programmes, it is still too early to ascertain whether this time around it will be able to do so. That is one of the major challenges which the AfDB has to tackle.

Similarly, the OAU also signed a number of agreements with the World Bank, UNESCO and other international organisations. Given the low levels of effective co-operation among them, it is not clear how useful these arrangements have been, except in the attendance and organisation of seminars, conferences and workshops that seem to be of much interest than the promoting of serious research and development. This is because at the end of all these talks no resources are forthcoming for any long-term programmes.

The establishment of the Joint OAU/ECA/AfDB Secretariat, as part of the joint effort to promote the realisation of the African Economic Community under the Abuja Treaty of 1991, marks a further practical approach to regional co-operation and integration in Africa. However, neither the AfDB nor the OAU are strong in terms of their assistance for S&T infrastructure development, particularly at the regional and sub-regional levels. The AfDB lacks any policy on science and technology. Its educational lending support for skills development is restricted almost entirely to basic education. The AfDB also does not have any division where scientific and technological issues are dealt with. It is currently in the process of establishing an engineering department, partly because of it's lending for road construction and other physical infrastructure development. But it has become increasingly clear that the human resources requirements of Africa go further than basic education. High-level skills in S&T are required to help fight hunger, poverty and disease. Hence, the *New Partnership for Africa's Development* (NEPAD) initiative strongly calls on the AfDB to play a leading role in the financing of regional studies, programmes and projects. However, the AfDB's failure to fulfil similar calls in the Lagos Plan of Action (1980-2000) means that it has to seriously consider the NEPAD initiative especially in the financing of regional and sub-regional programmes and projects, such as transport, energy, disease eradication, environmental preservation, telecommunications and the provision of regional research capacity (see NEPAD, 2001).

In Chapter 6 we looked at the sub-regional approach towards the development of scientific and technological co-operation programmes within SADC and ECOWAS. The common trend in both institutions is that their establishment treaties call for scientific and technological co-operation among their member states in order to develop their national and regional scientific capability. However, neither institution has any organisational framework which deals with the broader context and the varied fields of S&T for socio-economic development and therefore nobody to help develop and prioritise scientific and technological R&D and infrastructure at the sub-regional level.

Nonetheless, in view of the importance of the agricultural sector in both national and regional economies in the geographical purview of these two institutions, agricultural science and research dominates their programmes and they have created organisational structures specifically for that purpose. Within the SADC region co-operation in S&T can be found in the Food, Agriculture, and Natural Resources Sector, which has a number of programmes in the different sub-sectors where agricultural research and training has dominated. In this sense the institutionalisation of SACCAR, and its co-ordination activities in the creation of scientific infrastructure, particularly in higher education and training in agricultural sciences and research, has been established. SACCAR has since 1984 been the main body for effective agricultural R&D, as well as human resource development in agriculture in the Community. A number of scientists have been trained, which has enhanced the skills capacity of the region and its human resources. SACCAR has proved to be an institution through which donor confidence and trust have not been betrayed. Lending support to the programmes of SACCAR in education and research training is the new SADC Protocol on Education and Training, which has opened the door for co-operation in education and training not only in agriculture but other fields of knowledge in member countries.

However, the ongoing restructuring and rationalisation of SADC since March 2001 does not indicate what the future role of SACCAR, as the main body for regional agricultural research and training, would be. Compounding the instability of the situation is the fact that SADC itself still has no Unit dealing with S&T, nor will it have until the new restructuring is completed. S&T is still in limbo and, indeed, not yet firmly placed on the development agenda of the Secretariat. Ironically efforts by South Africa to help with the creation of such a unit within SADC is still far from realisation. Within ECOWAS the creation of the

Department of Industry, Agriculture and Natural Resources at the Secretariat in 1984 provided the initial organisational framework for the common development of agriculture in the sub-region. However, until there is a Unit and individual staff to take responsibility for and address the broader question of S&T policy development, international co-operation and the co-ordination and harmonisation of individual national policies and programmes, and regional programmes will be very difficult to formulate and implement.

A fundamental weakness of all the co-operation programmes on a sub-regional level is that they are often donor created or tailored to be donor approved, donor monitored and sometimes donor executed and evaluated. A regional programme development often depends on both bilateral and multilateral donor institutions for funding and thus, by implication, has to depend on the research interests of such organisations in order to secure funding. This also means that, whenever there is a change of research agenda in those institutions, SADC or ECOWAS research proposals have to be reviewed to accommodate donor demands, making long-term sustainable funding for research unattainable in such situations.

The over-reliance on external donor grants for the development of sub-regional programmes and their implementation has, however, become a matter of concern to regional policy-makers. For example, SACCAR is donor created and over 80% of its programmes are still donor supported, managed or executed. This donor dependence can only be reduced through active political commitments from leaders, especially the commitment to pay their country's contributions to SADC and ECOWAS to promote scientific research and development.

Most member states in SADC and ECOWAS experience a lack of scientific research and training infrastructure. Most of these countries cannot develop the appropriate infrastructure required for national development on their own, let alone for the whole region. This implies that very strong political commitments have to be made to establish effective and efficient regional infrastructure for scientific training and development. Until both SADC and ECOWAS member countries begin to accept greater responsibilities in some of the major programmes, which are designed to provide avenues for sustainability of research and development and human resources development, especially at the postgraduate level in science and technology, there is no prospect of a really sound sustainable future for scientific and technological co-operation in the two sub-regions under discussion; the same conclusion applies to the rest of the continent. This also means that it is important to speak of international co-operation in the broader sense, rather than regional or sub-regional co-operation in a narrower sense. Besides, most of the programmes promoted by the international institutions are often not peculiar to Africa but part of the international research agenda.

In view of this, the study asks what ECOWAS and SADC as well as other sub-regional institutions and the two main regional institutions, especially the OAU and AfDB can learn from similar institutions elsewhere, particularly the EU and ASEAN.

From the discussion in Chapter 7 we conclude that co-operation in S&T is firmly placed within the socio-economic development programmes in both the EU and ASEAN, but especially strongly in the EU. The treaty provisions of both institutions are a very important source of instruments for the promoting of scientific and technological co-operation among member states. The provisions of the treaties are, however, not a sufficient guarantee for promoting scientific co-operation and there has therefore been a need for the creation of an institutional framework within these provisions. The European Commission, particularly the Commissioner for Research and the Directorate-General for Research, is basically responsible for the broad scientific and technological research and development programmes within the EU. However, given the broad nature of S&T, they work closely with the other Commissioners, e.g. the Commissioner for Industry and Agriculture and their directorates and other relevant bodies or institutions within the framework of the Union, to formulate research policies and help in identifying European priority areas for research, particularly in the Framework Programmes. Through the Framework Programmes, the collective awareness of and attention to regional science and technology programming is now institutionalised in the European Union, enhancing co-operation and integration and European international competitiveness. The Union is also using part of its Structural Funds to support scientific infrastructure development and technological innovations in the less developed areas within member states.

Similarly, providing a strong S&T organisational structure was a preoccupation of the authors of ASEAN S&T co-operation long before they started with regional S&T programmes. Through COST and its nine Sub-Committees, which represent the prioritised areas of research required for building a strong ASEAN economy as well as international competitiveness, ASEAN now has a sound foundation for scientific co-operation. However, a major weakness of ASEAN is that regional S&T programmes are basically supported by external donor funding or, to put it another way, their dialogue partners. However, ASEAN has recognised this imperative and has responded by instituting an ASEAN Science Fund in 1989, with seed contributions of US$50 000 from each ASEAN member state, and the

ASEAN Fund, which has set a target of raising US$10 million as seed money for regional programmes. Development of the required scientific and technological infrastructure and necessary skills are a part of the regional approach.

Programme themes, including food science and technology, biotechnology, microelectronics and information technology, material sciences and technology, non-conventional energy research, meteorology and geophysics, and infrastructure and resources development are among the prioritised areas of research and technological development in both the EU and ASEAN, with the EU now moving into an additional field, nanotechnology, as one of the areas of European research. Building a knowledge economy anchored in instruments of knowledge-based development is therefore the driving force currently encouraging scientific and technological co-operation among these countries, in order to promote regional competitiveness as well as sustainable socio-economic transformation and development. The benefits of techno-regionalism in addressing individual national scientific and technological weaknesses are motivating factors. All in all, the realisation of the importance of science and technology in global development and competition, and the regional approach backed by regional policy and research institutions rather than narrow national interest, have been critical in the success stories of the EU.

8.2 RECOMMENDATIONS

The socio-economic as well as the political development of Africa on the basis of knowledge-based development anchored in scientific research, innovations, education and training will require a number of measures that are in no way mutually exclusive but rather inter-related and intertwined.[1] These measures include *inter alia:*

8.2.1 Promoting Science and Technology Policy Studies

The socio-economic transformation of the African economy will largely depend on the need for manpower training in policy-making (science, technology, research and management).

Therefore African universities should embark on postgraduate training programmes or courses in the field of S&T policy studies on a similar pattern to that of the Science Policy

[1] I am aware of the of the Declaration on Science and the Use of Scientific Knowledge and its Framework for Action at the UNESCO World Conference on Science in 1999, which many African countries now see as the global blueprint for scientific and technological development. However useful it may be, I still believe that most of the effort should come from African countries and institutions, given the past disappointments after such global conferences due to their failure to follow up with the implementation of their Programmes for Actions, e.g. 1979 UN Conference on S&T.

Research Units of the Universities of Sussex and Manchester in the United Kingdom, the Massachusetts Institute of Technology or the Research Policy Institutes of the University of Lund, Sweden. The courses should, however, be tailored to and address the needs of the African continent, particularly in endogenous technical knowledge and in developing technologies addressing the specific needs of African countries.

At the time that Forje (1989:82) raised this issue few African universities had recognised the need for having S&T policy studies included in their curricula. For example, in West Africa only the University of Ife, in Nigeria had a Science Policy Unit; the University of Dar-es-Salaam in Tanzania also had a programme in S&T policy in East/Southern Africa. The number has now increased slightly, with the University of Stellenbosch having Masters of Philosophy (MPhil) and Doctor of Philosophy (DPhil) programmes in Science and Technology Policy Studies at the Centre for Interdisciplinary Studies, established in 1996; the Development Policy Research Unit, which is part of the School of Economics of the University of Cape Town, also created a Science and Technology Policy Research Centre in July 1995. Both of these Centres have been recognised by the Centre for Science Development (CSD) of South Africa as national research units.

Very few science and technology policy think tank groups or institutes exist outside the university system in Africa. The lack of appropriate S&T indicators attests to this. It is also not surprising that much of the work on the socio-economic analysis of science and technology in Africa has come from scholars and researchers based outside the continent. Otherwise any strong or functional S&T policy research centres are supported by outside agencies, for example, the International Development Research Centre (IDRC - Canada) and the Carnegie Corporation, among others, support the African Technology Policy Network based in Nairobi, Kenya. Yet at most of these centres research and studies are still concentrated on the level of individual countries and few of their studies are concerned with analyses at the regional and sub-regional levels in Africa. Some of these centres should broaden the scope of their programmes to cover these two levels.

8.2.2 S&T Organisational Framework

The creation of an appropriate organisational framework within the regional and sub-regional institutions is very important for the promotion and institutionalisation of regional science and technology co-operation. Although the OAU Scientific and Technical Research Commission based in Lagos, together with its sub-regional offices, provides such a continental framework, the current structure needs reform to make it really functional. The OAU/STRC cannot effectively co-ordinate the activities of the other sub-regional offices, let alone those of member states. Besides, a firm decision has to be taken either to close the S&T representation at the OAU Head Office in Addis Ababa and relocate the staff to Lagos or, alternatively, the Lagos Office should be moved to Addis Ababa. This has been one of the major problems that African leaders have failed to resolve since the creation of the OAU and which has continued to be a stumbling block in the way of the establishment of an effective and efficient regional structure of S&T co-operation and development in Africa. As it currently exists, neither the office in Lagos nor the representation in Addis Ababa can provide an effective overview of S&T co-operation and activities at the regional level in Africa. Science and technology should also be given a separate department or directorate within the structure of the OAU/AU and an effective mechanism should be developed to enhance co-operation and co-ordination.

At the sub-regional levels neither ECOWAS nor SADC has an organisational structural framework for dealing with the overall S&T programmes and activities. Although some recommendations have been made in the past, the policy makers have so far failed to implement such recommendations. Sadly, the restructuring of the current SADC institutions has failed to provide an appropriate body whereby the region's S&T programmes and activities can be facilitated. However, from our analyses of the EU & ASEAN, we realise that it is not possible to implement scientific and technological co-operation programmes without an appropriate institutionalised organisational framework to prioritise, facilitate and co-ordinate these programmes. Similarly, the AfDB has no effective programme or policy for supporting S&T in Africa, because it has failed to establish a department to handle S&T issues and to provide funding support. This means that the development and management systems for S&T programmes in the current regional and sub-regional institutions lack any institutionalised framework and so rectifying this situation should be given a high priority. The AfDB can learn a great deal from the S&T financing activities of the Inter-American Development Bank (IDB).

With the appropriate framework, some regional centres of excellence can be selected to provide support for regional policy formulation and act as representatives during international negotiations. Without such centres to provide technical assistance to regional policy-makers and the negotiators of international agreements, Africa cannot provide any substantial and empirical evidence to support its position. Obviously, as John Ruggie would argue, while

S&T is not the only field for which international relations are necessarily recast (see Wœver, 1997:174), it nonetheless plays a fundamental role in trade and development as well as security issues.

8.2.3 Exploring New Public-private Partnerships

There are increasing calls for a new kind of partnership between the public sector and private sector (both profit and non-profit), particularly in developing countries and regions. Since Africa's economy is still at the basic agrarian level, the best set of partnerships to explore lies in research in the agricultural sector. The two examples of co-operation at global level to promote agricultural development that readily come to mind are the International Service for Acquisition of Agri-Biotech Applications (ISAAA) established in 1991, and the Private Sector Committee of the CGIAR system, established in 1995. Philanthropic foundations, bilateral organisations and private corporations both provide financial support to the ISAAA and use it to share their biotechnology applications. The primary objective of the ISAAA is to promote the transfer of agri-biotechnology from the industrial countries in the North, particularly proprietary technology from the private sector, to developing countries (James, 1996 cited in Pray & Umali 1998:1143). The CGIAR has also set up a Private Sector Committee to explore opportunities for greater CGIAR-private sector collaboration in agricultural research (Özgediz, 1997 cited in Pray & Umali-Deininger, 1998:1143).

As regional and sub-regional institutions seeking to establish these new forms of partnership, the OAU (now AU) and the other sub-regional organisations should carefully examine the partnerships mentioned above to determine their suitability to the African situation. It should also be borne in mind that the African continent currently has the least investment worldwide from private sector research, even in agricultural R&D.

Obviously, the private, non-profit, international institutions have played and can still play a pivotal role in the future of S&T capacity building in Africa. Institutions such as the Ford Foundation, Carnegie Corporation of New York and the McNight Foundation, all based in the USA, have been supporting individual scientists. Since 1996 the Carnegie Corporation, Rockefeller Foundation, Andrew W Mellon Foundation, Ridgefield Foundation, Coca Cola Foundation, Quaker Chemical Foundation, Engineering Information Foundation and the Rockefeller Brothers Incorporated have supported universities' Science, Humanities and Engineering Partnerships in Africa (USHEPiA) programme co-ordinated by the University of Cape Town in South Africa. This is an example of NGOs support for regional S&T co-operation involving a number of universities, researchers and joint supervisors in Southern and Eastern Africa for human resource capacity building.[2] Currently, the ongoing research areas include molecular and cell biology, geomatics and geographical information system (GIS), engineering management, chemical engineering, mining engineering, gender studies and education. Between 1996-2001 academic years 39 fellowship awards were given (excluding short-term fellows), out of which 11 doctoral degrees and 5 masters degrees have been awarded through the USHEPiA fellowship programme so far. A very distinctive feature of the USHEPiA programme is the provision of re-entry grants to visiting researchers to enable them to upgrade their local research environment including the purchase of personal computers, printers or scanners upon returning home from South Africa. The importance of this programme is that it is based in Africa and the training is also taking place in Africa.

8.2.4 Intellectual Property Rights

Discussing public-private sector partnership in research and development to promote socio-economic transformation and development often brings up the thorny issue of intellectual property rights protection. With an increasing commodification of knowledge and knowledge production, it should be established that any agreement aimed at knowledge for development in partnership with the private sector should make adequate provisions for the fundamental issue of dealing with intellectual property rights. If even scientific collaboration involves states or public institutions acting across borders this issue should be recognised, since the potential utilisation of the end result for commercial purposes by any one of the partners could lead to protracted legal battles. This became one of the reasons why the first OAU draft science and technology protocol, which made no provision for intellectual property protection and commercialisation of research results, was never finalised or adopted.

Furthermore, as recently revealed, the OAU's Model Law on the Protection of the Rights of Local Communities, Farmers and Breeders and the Regulation of Access to Biological Resources of African biodiversity and genetic resources encountered problems with the World Intellectual Property Organisation (WIPO) and the Union for the Protection of New Plant Varieties (UPOV). This points out how difficult any partnership, even with international organisations, can be. These two organisations are demanding that the Model

[2] At present, there are 8 USHEPiA partner institutions which include: Jomo Kenyatta University of Agriculture & Technology (Kenya), Makerere University (Uganda), University of Botswana (Botswana), University of Cape Town (South Africa), University of Dar es Salaam (Tanzania), University of Nairobi (Kenya), University of Zambia (Zambia), and the University of Zimbabwe (Zimbabwe).

Law be rewritten to suit private property and the protection of plant varieties through patents or a *sui generis* system. The reality is that, while it is good to promote scientific research as being in the public good for consumption, any institution which neglects to provide adequate mechanisms for dealing with intellectual property protection in this era of commodification of knowledge and knowledge production is bound to face major challenges from the private sector.[3]

8.2.5 Establishing Regional Funding for S&T

Increasingly, one of the major issues raised is the continuous lack of wherewithal to support regional or even national S&T programmes and activities. The problem here is that most programmes require sustainable funding and that which currently exists in Africa at the regional or national level is derived from outside agencies. For example, UNESCO created the International Fund for Technology Development in Africa under its Priority Africa Programme with an initial seed donation of US$1 million, which was expected to attract donations from other donors. UNESCO started using the network income from this fund to finance projects under its university-industry linkage programme (UNISPAR) (Odhiambo, 1996:142) and the SPAAR programme is also World Bank driven. African institutions should take initiatives towards establishing S&T Funds at either the regional or sub-regional level to promote and support regional R&D and infrastructure development. The ASEAN and EU initiatives are worthy examples, but that of ASEAN most important as it is also in a developing region.

At the individual national level our analysis of the World Bank lending patterns shows how the African continent has been marginalised in terms of the Bank's support for S&T programmes in the past. The Bank's Millennium Science Initiative (MSI) and the Heavily Indebted Poor Country (HIPC) initiative now provide an opportunity for individual national governments in Africa. Most of those countries that have qualified, or are due to qualify, for the HIPC programme should build scientific infrastructure and research and development into their programme proposals for funding (see UNESCO's Proposal on Debt Relief).

Those infrastructures thus selected for development should aim at becoming regional centres of excellence. There are many fields of S&T where there are either no facilities, or centres with limited capability for rigorous research, in Africa in terms of both physical facilities and

[3] See OECD, 1999, for more on the discussion on intellectual property and genetic resources particularly in the developed countries.

human resources. These fields include biotechnology, information and telecommunications technologies, microelectronics, pharmaceutics and now also nanotechnology. The concern here is that not all African countries can afford to create individual research centres to conduct effective R&D as well as skills training. With the appropriate regional organisational structure, S&T management and development should aim at creating infrastructure for techno-regionalism and innovative ways of building a functional regional system of innovation.[4] This will be in line with promoting and facilitating regional competitive advantage. Above all, this means that financial inputs into S&T development and research ought to be considered as an investment factor, as opposed to the existing mode of treating research as a consumption factor (to borrow terminology from Krishna, Waast & Gaillard, 1998). The International Centre of Insect Physiology and Ecology (ICIPE) based in Nairobi, Kenya in partnership with a consortium of 17 participating universities from West, East, Northeast and Southern Africa developed the African Regional Postgraduate Programme in Insect Science (ARPPIS) in the 1980s, which is a worthy example of an indigenous African initiative (see Odhiambo, 1991:6-7). Despite its success, it is donor dependent and in the past struggled to be selected as one of the CGIAR centres. The question remains, how can African governments be able to at least create and support such a regional centre of excellence whose programmes are relevant to the socio-economic development of the continent?

8.2.6 Democratic Governance

Democratic governance in recent times is influencing the patterns of scientific and technological co-operation and alliances. Whether at the corporate, individual or inter-state level, co-operation among democratic states or institutions involving researchers from all these is being promoted. The World Bank, the African Development Bank and other development finance institutions are including democratic or good governance as a condition for lending. Increasingly, as regional and sub-regional institutions become the channel through which funds are provided to member states to promote co-operation and integration, institutions in Africa should seek to ensure that individual members conform to democratic and sound principles of governance.

The reason for this insistence is that democracies do not easily make war on one another. The regional and sub-regional institutions have a greater role to play if the regions are to develop.

[4] The term regional systems of innovation (RSI) is used here with a much broader application than in the discussion by Jeremy Howells (1999), who views RSI as a subset of national systems of innovation (NSI). From regional or sub-regional levels of analysis, as in this study, NSI can be taken to be a subset of RSI.

Certain events in SADC and ECOWAS, and the current political instability in some of the member states do not augur well for future development. Although the establishment of the ECOWAS peacekeeping monitoring group (ECOMOG) provided some basis for peace in the conflict-prone states of ECOWAS, the idea of ECOMOG was the initiative of only a few member states: collective efforts would have brought peace much earlier. Besides, political instability in Africa and elsewhere has shown that development efforts can be plunged into a downward spiral lasting many years. Democratic governance can also help to create a congenial political environment for general socio-economic development and transformation.

8.2.7 Promoting S&T Collaboration

The level of inter-African collaboration in S&T production in terms of individual scientists and researchers is still one of the lowest in the world. For example, a study in 1994 based on the database of SCI showed that among the top five S&T production countries in Africa (Algeria, Egypt, Kenya, Nigeria and South Africa) there was very little co-operation that has resulted in co-authored papers. Out of 1692 papers that were co-authored by Egyptian scientists, the only collaborations were with Algeria (2). Similarly, of the 3025 co-authored papers by South African scientists, 1 was with a Nigerian, 3 with Egyptian and 4 with Kenyan scientists and researchers. South African scientists, meanwhile, co-operated with scientists from Brazil (13), Chile (12) and Argentina (4) in fields including astronomy and astrophysics (FRD, 1996:138-9).[5] The other three African countries did not have a different pattern: Nigerian scientists co-authored 5 papers with their Kenyan partners; this was the highest figure for co-operation. The low level of collaboration has not changed very much and it is therefore one of the major challenges, which the individual professional organisations and networks have to address by encouraging their members from different countries to collaborate in knowledge production. The African Academy of Sciences and the Association of African Universities (AAU) should play leading roles in this direction.

8.2.8 Institutionalisation vs. Personalisation of Programmes

The apparent lack of institutionalised programmes has also been one of the major problems affecting the sound development of S&T programmes in Africa. In Africa personalities tend to determine the success or failure of a programme. Most programmes are developed by an

[5] It still not known how the new South African government programmes for S&T co-operation and the NRF Africa-interaction programmes as well as the USHEPiA programme will increase collaboration and co-authored papers in the next review of SA Science and Technology Indicators.

officer in-charge of co-ordination and implementation. Once the person's terms of office or contract expires, or he/she is fired, there is no further continuity of the programme(s) and, in most instances, no critical evaluation is conducted to determine whether the programme(s) should be discontinued or not. Since institutions are not known to have programmes, a dismissal of or change in leadership usually also means the end of the programme(s). To avert the frequent occurrence of over-personalisation of programmes, there should be sustained effective monitoring and evaluation of programmes, which is the only way sustainability of programmes can be ensured and the completion of projects attained. It will further help to provide objective analysis if any policy change or programme change is required. It is often forgotten that policies and programmes are never developed by an individual alone and that a team or group may have helped in the development or have provided useful inputs and suggestions, notwithstanding the fact that one person assumes the overall responsibility.

8.2.9 Policy Harmonisation and Rationalisation of Institutions

Professor Michael Porter (1998) of the Harvard Business School talks about the competitive advantage of nations in which a national system of innovation is very important. However, in the current world political economy it becoming increasingly clear every year that the competitive advantage of regions is now the driving force influencing regional co-operation and integration. As regional competitiveness for a share in the world trade in goods and services has led to increasing harmonisation of national policies, in line with regional co-operation and integration policies and programmes, it is very important to put forward a regional system of innovation in policy formulations and programmes. The actual adoption of a single European currency (the euro) on 1 January 2002 attests to the significance of policy harmonisation.

In Africa the lack of harmonisation and co-ordination of national policies remains the biggest problem in the way of good regional co-operation and integration. Besides, there are so many regional and sub-regional organisations in Africa which duplicate their aims and objectives that they all fail to achieve anything useful for their members.[6] In the ECOWAS region the

[6] This is even evident in internal politics, where the recent return to party politics in Africa has witnessed a proliferation of political parties – more than are necessary during an election year. In particular, the opposition failure to win the December 2001 presidential elections in Zambia is a clear example. There were 10 opposition parties challenging the ruling party. In the end the ruling party won with less than 30% of the national vote. The opposition then united to challenge the result in court. They had not, however, been able to unite before the elections to form (at most) three parties in order to challenge the ruling party effectively.

number of regional groupings is high, yet the region is less integrated than it should be because there are rarely any regional programmes that are functional.

8.2.10 Developing Regional Science and Technology Indicator Systems

Related to the harmonisation of policies is the need to establish a regional system of science and technology indicators to promote effective and efficient planning and programming at both the national and regional levels. The lack of credible data on S&T has already been highlighted, but the creation of a regional database could help the various regional organisations to prioritise their programmes. That is why having an S&T organisational framework within each of the various institutions is absolutely crucial. To develop such a system the African institutions can learn from both the EU and ASEAN. In fact, the latter's ASEAN COST Sub-Committee on S&T infrastructure and Resources Development (SCIRD) established an Expert Group on S&T Indicators in 1995, which helped to develop the first Science and Technology Indicators in ASEAN.[7]

8.2.11 International Donor Support for Regional Programmes

One of the assumptions of this study is that for Africa to develop its S&T capability for sustainable development, it will continue to need human and financial assistance from its development partners, both bilateral and multilateral. While most government programmes as well as regional ones are donor supported or engineered, programmes in the past have not really helped in developing the appropriate infrastructure (both human and physical) within Africa. For example, most Commonwealth Scholarships awarded to Africans for training, especially at postgraduate level, have been meant for training outside Africa in the developed countries. This means that there has been no real motivation for the development of advanced infrastructure for scientific training and research in most African countries. It also means that scientists trained abroad often return home, where they find that there are not the same facilities for their work and this therefore acts as an incentive for to them leave, hence the brain drain. The Commonwealth Split-Site Scholarships are now attempting to address this problem. The German government's support for SACCAR postgraduate training, UNESCO's

[7] Since the publication of the Frascati Manual on S&T indicators in 1963, it has been revised and expanded five times and the sixth edition of the manual is due this year, 2002. Other manuals that could be of use are the Oslo manual on Proposed Guidelines for Collecting and Interpreting Technological Innovation Data 1992 (revised 1997), the Canberra Manual on the Measurement of Human Resources Devoted to S&T in 1995 (see OECD, 2000). These manuals, together with the ECA's 1995 study, could serve as appropriate guide to help develop Africa's S&T indicators system.

ANSTI Programme and the USHEPiA mentioned earlier are also examples worth mentioning. However, the development partners could still do a lot better than their current efforts to a provide a solution. In particular, infrastructure support should aim at building regional or sub-regional centres of excellence and specialisation. Most of the current programmes are nationally focused and experience decreasing support as a result of so-called donor fatigue; it would be more judicious and appropriate to support regional or sub-regional programmes that would promote co-operation and development.

8.2.12 Technology Transfer

From our analysis, especially using the SPAAR evaluation of sub-regional agricultural research institutions, we realised that the need for effective and efficient modes of technology transfer in Africa cannot be over-emphasised. Whether in terms of hard and soft technology, it is still very low among African countries and even between Africa and the rest of the world. Africa needs to double its efforts in technology as well as science transfer. One of the major failures of the past donor-sponsored programmes is that external expertise contracted to develop and implement such programmes or projects do not adequately equip the beneficiaries of the programmes well enough to oversee the maintenance of the programme after such external experts have left. These are some of the challenges which the regional and sub-regional institutions in Africa should be addressing in the area of technology transfer.

However, the question of technology transfer in the aftermath of the 11 September 2001 attacks on the Twin Towers of the World Trade Centre in New York and the Pentagon (the epicentre of USA's national security in Washington DC) raises a number of issues that may mitigate against North-South and even South-South technology transfer, most importantly those technologies considered as dual-use. In the wake of the "War on Terrorism" the likelihood of a body similar to the Co-ordinating Committee on Multilateral Controls (COCOM) formed by the developed countries with membership extended to the North Atlantic Treaty Organisation (NATO), which ensured embargoes on dual-use technologies and that goods were not sold to the East (in the Cold War era), may be established. After all, one of reasons for the failure of the US to detect the plan of the attack is attributed to the closing of the scientific and technological gap. For instance, former US President Bill

Clinton's decision to relax restrictions on exports of data-scrambling software has led to the spread of cryptography software commercially since 1999.[8]

Secondly, the transfer of skills and the acceptance for training of people from developing countries in certain scientific and technical fields in the USA and other countries of the North are now going to be subjected to more restrictive rules and the regulations will be stringently enforced. The first casualty of this human resources development will be the aeronautics sector, given that some of the hijackers were trained in US aeronautical schools. Furthermore, the anthrax problem in US indicates that the person(s) who produced the strain contained in a letter that was sent to the US Senate Majority Leader could be a holder of doctoral degree in microbiology. This also holds serious implications for scientific exchange programmes between North and South or even South-South involving students and researchers alike, since entry visa applications are going to be assessed more stringently than before.

However, if African regional and sub-regional institutions can develop common programmes and achieve or encourage good governance in their member states, restrictions on technology transfer and the human resource capacity building should not be severely restricted in terms access to knowledge and related technology. The transformation of the OAU into the Africa Union and the NEPAD initiative provides a better platform, where issues of technology transfer could be firmly placed on the agenda for development programmes and details developed to that effect.

8.3 A WORD OF CAUTION AND FUTURE RESEARCH

Vannevar Bush, in his popular work *Science, the Endless Frontier,* warns us against being too S&T deterministic, because S&T alone cannot bring about sound economic growth and development. According to Bush (1945:11), "science, by itself, provides no panacea for individual, social, and economic ills. It can be effective in the national welfare only as a member of a team, whether the conditions be peace or war. But without scientific progress no amount of achievement in other directions can insure our health, prosperity, and security as a nation in the modern world". Therefore, we are not making the mistake of saying that S&T alone will bring about the socio-economic development and transformation of every nation and region, or improve the state of the global political economy. However, its sound

[8]William J Broad 2001. "Rapid growth in commercially available technology erodes US edge in spying" *Sunday Dispatches, The Sunday Independent* 23/9/2001:13.

application and management can significantly help to fight hunger, disease and poverty, especially in Africa. At the institutional level there is indeed a greater need to conduct more research at the regional and sub-regional levels, and to encourage and enhance the institutionalisation of scientific and technological co-operation in the discourse of knowledge for development. As Nederveen (2001) argues, international development co-operation has been shifting or changing in different ways and the emphasis has shifted from bilateral to multilateral co-operation through international and regional institutions.

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AfDB	http://www.afdb.org
ASEAN	http://www.aseansec.org
ECA	http://www.uneca.org
ECOWAS	http://www.ecowas.int
EU	http://www.europa.eu.int
IDB	http://www.iadb.org
OAU	http://www.oau-oua.org
SADC	http://www.sadc.int
SADC Review	http://www.sadcreview.com
UN	http://www.un.org
UNCTAD	http://www.unctad.org
UNDP	http://www.undp.org
UNESCO	http://www.unesco.org
WHO	http://www.who.org
World Bank	http://www.worldbank.org
Altavista	http://www.altavista.com